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PIPPA'S PROGENY

RECENT comment has tended to suggest that the Calder Hall reactors are already out of date. This judgment is a little premature, and though one day they may indeed be looked upon as the Model T of reactor engineering, that time has not yet come. The Model T Ford has, in any case, proved long lived and may even now be seen running about the Middle West—or so we understand. But whatever novel designs are envisaged, PIPPA, the gas-cooled graphite-moderated system on which the Calder Hall reactors are based, is likely to remain vigorous and fertile, with numerous offspring to her credit.

Sir Christopher Hinton has said that reactors of this kind will enable Britain to retain her lead for at least a decade, and that basically similar installations will still be built in 25 years. Since the Geneva conference in August, 1955, both the United States and the Soviet Union have undertaken gas-cooled reactor projects, flattering our choice by imitation and showing our advocacy to have been convincing. Sir John Cockcroft has suggested that the sodium-graphite reactor (one of the systems proposed for Stage II of the United Kingdom programme) may in fact prove no more economical or adaptable than advanced forms of gas-cooled reactor. A more positive attitude may be revealed at to-day's closed conference at Harwell on advanced reactors; perhaps reactor feasibility studies have shown the gas-cooled system to offer far better prospects than was originally believed. It would not be the first time that an early solution to a problem has proved the most enduring. In locomotive engineering, for example—with which Sir Christopher Hinton has had some acquaintance—Stephenson's fire-tube boiler (gas-heated in this case) and his ingenious system of using cylinder exhaust to generate furnace draught, have survived in spite of many experiments since. Perhaps, in the same way, the gas-cooled reactor will outlast other more revolutionary designs.

It is extremely difficult to compare different reactor systems; the factors involved are numerous, and a reactor suitable for one application or locality may be found to have serious disadvantages elsewhere. Indeed, the British choice of a gas-cooled system for the plutonium factories at Windscale arose from Britain's own peculiar circumstances: population is dense—so an inherently safe system was necessary; no large source of pure water for cooling purposes was available as at Hanford in the United States—so air cooling was adopted. We were thus led to favour gaseous coolants from the beginning. But now we are committed, there is something to be said for concentrating on a system we know something about—a system using comparatively cheap natural or slightly enriched uranium—and neglecting other less likely designs. This is particularly true where comparison between different reactor systems proves inconclusive.

But there are other considerations to be borne in mind. Power reactors are likely to be complementary, some breeding fuels which can more economically be burned in others. There are also reactors which in prospect at least are far superior to other systems. The homogeneous reactor, for example, in which fuel, moderator and, in effect, primary coolant are intimately mixed in a solution or slurry, has potentially incomparable advantages, once its associated technical problems have been solved. It offers continuous fuel processing within the reactor plant itself and enhanced heat transfer, and may in fact introduce an age of cheap power—possibly 0·4*d.* per kWh sent out as against to-day's price of 0·6*d.* In addition, gas cooling may be inadequate in fast reactors such as that building at Dounreay and in others with small highly enriched cores, where the heat output density may be very large. Here it may be necessary to use liquid-metal coolants. Thus it would be rash to ignore all other possibilities, and a fairly broad programme is desirable. Reference is made to some alternative systems in an article dealing with the future development of reactor technology on page 694, while three selected systems will be discussed in greater detail in subsequent articles.

But the attraction of novelty should not blind us to PIPPA's graces. Part of the article in this issue is devoted to the immediate advances which are possible with this system. Thus the initial C.E.A. stations at Bradwell and Berkeley are likely to have three times the output of the 92 MW Calder Hall "A" Station, with little increase in capital cost. Later, the very-high-temperature (VHT) gas-cooled reactor, using an enriched ceramic fuel dispersed in the graphite moderator, may become practicable. This design has many potential advantages, such as the exclusion of all metal from the reactor core, the high efficiency associated with high coolant outlet temperatures (perhaps 800 deg. C.) and the elimination of heat exchangers by use of a closed-cycle gas-turbine system.

The men who designed the Calder Hall station were limited to techniques and materials available at that time and did their work accordingly. Thus the plant might seem an uncomfortable assembly of ill-assorted components—rather like a laboratory test rig made from any spare parts that happened to be handy. Yet in spite of

XUM

overwhelming design limitations, Calder Works is almost equal in performance to a conventional power station, even though its main purpose is producing plutonium. Thus now that new materials and techniques are being developed, specially adapted to nuclear engineering, we may expect remarkable advances. Prospects for the gas-cooled reactor are therefore considerable. There is no sign of PIPPA passing yet.

* * *

Plain Words

The industrial consequences of the Suez situation are as full of mirages as the neighbouring Sahara. Despite the shortage of oil and the rationing scheme which it has evoked, there is too much facile optimism about the economic consequences of the Suez blockage.

Allusions on the subject are not confined to politicians who have a vested interest in looking on the bright side. The strike of British Road Services drivers, which is discussed in this week's " Human Element," is a particular illustration of the illusion that the shortage of oil is no more than a question of drawing on local stocks. The impression is widespread even among managements that a certain amount of clever improvisation and switching to alternative fuels, or from road to rail transport, will do the trick.

Some of this wishful thinking is based upon the encouraging economic picture which comes out of October and immediately before the Israelis' march south. Exports were at a record level and the gold and dollar reserves were standing up well to seasonal pressure. Prices of basic raw materials for industry were also slightly down in October. To judge from the latest behaviour since the beginning of November of the main metals entering into international trade, there has been no acute worsening of the situation in the first three weeks of November in copper, tin, lead and zinc. The crisis found markets with high prices and no rush of buyers. In the case of copper, particularly, the underlying trend of prices was downward since production was considered to be ahead of demand.

These various indicators do not, however, foretell persistent and unshakeable prosperity. They could be the calm before the storm. One of the least attractive features of an economy such as that of the United Kingdom, with its heavy dependance on imports and exports and upon the terms on which they are traded, is the startling speed at which conditions can change for the better or worse. There is no doubt that if the oil shortage persists for long the volume of industrial production must suffer. It can suffer both from a decline in physical output and in the cost and speed of services, notably of transport. It is likely that unfavourable conditions will develop more quickly in services than in production. Be that as it may, a decline in industrial activity is bound to lead to rising costs in a country where employment and wages are no longer sensitive to changes in the volume of industrial output.

THE EXPERIMENTAL SPIRIT

2—TRIALS WITH FUEL, WATER AND FRONT-END MODIFICATIONS TO LOCOMOTIVES

By C. R. H. Simpson, A.I.LOCO.E.

The second of a series of articles on the unsuccessful attempts which have been carried out to make the steam locomotive competitive with electric and Diesel traction.

FUELS

Fuels normally used in locomotive fireboxes are coal, oil, peat and wood. The choice is usually dictated by economic conditions (which have, on occasion, even resulted in coffee beans being employed) though each system has its advantages and disadvantages.

While there are some three operating advantages[28] likely to accrue from the use of oil, they are unlikely to be the reasons for burning it. In Britain it was used either as a means of disposing of petroleum waste—as in the Great Eastern Railway application in the early years of the century—or when coal was in short supply. During the coal strike of 1921, engines of the H.R., G.W.R., G.C.R., Metropolitan, L.S.W.R., L.N.W.R. and G.E.R. were among those fitted with either Holden's or " Scarab " apparatus. Previously, in the strike of 1912, the Caledonian and Midland railways also embarked on conversion. The fiasco of 1946, when the Minister of Transport authorised the four groups to proceed as quickly as possible with the conversion of no less than 1,217 locomotives, for which subsequently oil was not available, will still be fresh in readers' minds.

The most interesting departure, so far as locomotive fuel in Britain is concerned in the period covered by this survey, was the experimental use of pulverised coal. The underlying idea was the use of a lower grade coal—at a reduced price—than could be fired by other methods. There was also the added point that coal which could not be stored without disintegrating could be used by this method, and in theory it offered most of the advantages of oil firing so far as ease of handling, etc., were concerned. Between 1916 and 1924 a phenomenal increase took place in the use of pulverised fuel for stationary work in the United States, and in Germany in 1926 over 2½ million tons of dust fuel were used.[29]

During the first World War, five American railroads carried out experiments. In 1924 the A.E.G. Locomotive Works in Germany took up the study of applying this fuel to locomotives; the Stug system was developed by Henschel und Sohn. Swedish locomotives were converted to burn pulverised peat during the first World War.

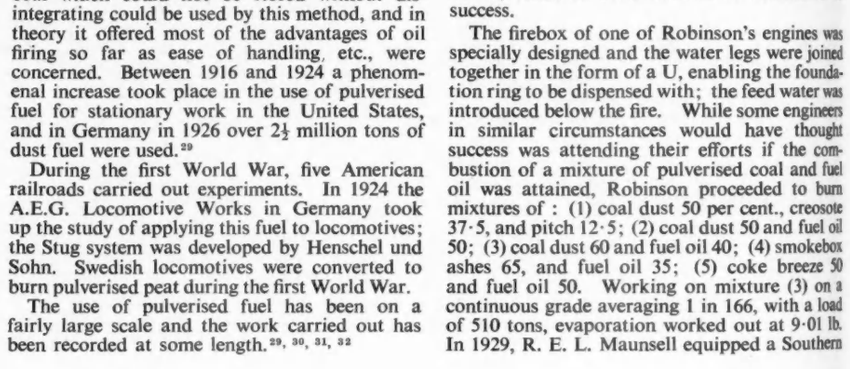
The use of pulverised fuel has been on a fairly large scale and the work carried out has been recorded at some length.[29, 30, 31, 32]

Stug equipment was ordered from Henschel und Sohn for two engines for the Victorian Railways. Trials on X Class 2-8-2 No. 32 and R Class 4-6-4 LP707 commenced in 1949 but the results of these are not known. The difficulties encountered have included excessive chimney losses (and hence very dirty working), the possibility of the fuel becoming caked in the bunker, the formation of slag on the tubeplate, and the danger of explosion. These factors, plus heavy maintenance costs and high initial cost, led to the view that pulverised fuel was uneconomical and not fool-proof.[33] On the other hand, if brown coal is the sole fuel available the opinion is held that the only satisfactory way to use it in a locomotive boiler is to pulverise it and burn it in powdered form.[34]

The first experiments carried out with pulverised fuel firing on locomotives in Britain were those conducted by Mr. J. G. Robinson on the Great Central Railway. They commenced in 1916 and were said[35] to have met with a " considerable amount of success." The grouping of railways after the war terminated the developments.

The conditions existing in the Stephenson boiler have been described[36] as the reverse of those desirable for pulverised fuel firing. The chief combustion space is the firebox and in the designs prevalent at the time of the early tests this would have had to be supplied with from 135,000 to 200,000 B.Th.U. per cub. ft. per hour if the same amount of steam was to be raised as by grate firing with good coal. This rate of heating is about ten times that usual in stationary pulverised fuel practice. The increase in firebox volume and the provision of a combustion chamber, which came after the initial experiments, rendered conditions more conducive to success.

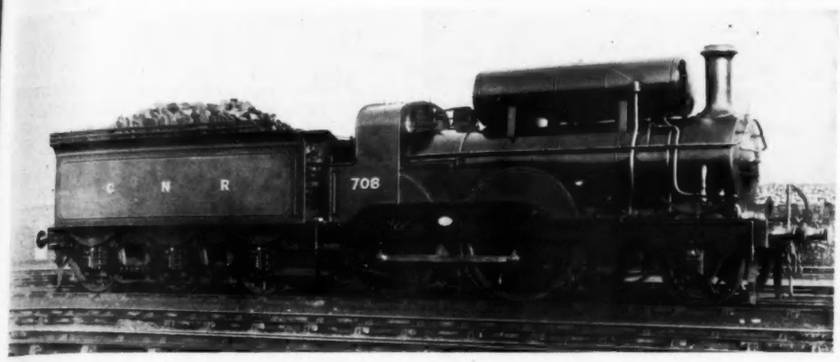
The firebox of one of Robinson's engines was specially designed and the water legs were joined together in the form of a U, enabling the foundation ring to be dispensed with; the feed water was introduced below the fire. While some engineers in similar circumstances would have thought success was attending their efforts if the combustion of a mixture of pulverised coal and fuel oil was attained, Robinson proceeded to burn mixtures of : (1) coal dust 50 per cent., creosote 37·5, and pitch 12·5; (2) coal dust 50 and fuel oil 50; (3) coal dust 60 and fuel oil 40; (4) smokebox ashes 65, and fuel oil 35; (5) coke breeze 50 and fuel oil 50. Working on mixture (3) on a continuous grade averaging 1 in 166, with a load of 510 tons, evaporation worked out at 9·01 lb. In 1929, R. E. L. Maunsell equipped a Southern



German locomotive with A.E.G. pulverised fuel firing.

Railway 2-6-0 (No. A629) with the A.E.G. system of pulverised fuel firing. The engine ran thus equipped until 1933.[37]

Not for the first or last time, experiments on the same subject produced vastly different impressions in different parts of the world. Experiments carried out with pulverised fuel in Brazil were so successful that the Brazilian Government was reported to have contracted with the Pulverized Fuel Company of New York for the equipment of 250 locomotives.[38] The Dutch Railways, duly impressed by the Brazilian experiments, equipped two locomotives with equipment supplied by the Fuller Engineering Company, also of the United States. In practice, steaming left nothing to be desired but combustion was so incomplete, due to burner trouble, that the windows of the carriages were covered with a coat of pulverised coal, making them opaque. The enginemen's faces were similarly transformed!



G.N.R. engine with Halpin thermal storage.

FEED-WATER HEATING

Feed-water heaters of one form or another have been applied to many locomotives and in many countries they became standard practice. As they were not transient fittings—though their use in Britain was somewhat limited and spasmodic—comments will be confined to those with a restricted application. The advantages of feed-water heating are so evident in theory as to need no explanation, but in practice the additional complication has prevented a more general use.

In the early years of this century, Mr. Druitt Halpin invented his thermal storage system which in Britain had a limited application on the Lancashire and Yorkshire Railway and to one locomotive on the Great Northern Railway. Briefly, the equipment consisted of a storage tank in which feed water was maintained at approximately the temperature of the boiler water. The tank was fed by injectors and when the boiler output was in excess of the demand, steam was fed from the boiler into the tank. While the use of steam to heat feed-water was general in feed-water heaters not depending on smokebox gases, exhaust steam was employed whereas the Halpin system employed live steam. Mr. Hughes stated[39] that where stopping places on rising gradients were frequent (i.e., where there were periods of hard steaming followed by cessation of demand on the boiler) there was distinct economy and tests carried out showed savings of the order of 12 per cent. When, however, the locomotives were used on sections where the conditions were less severe, the all-round economy dropped to about 4 per cent. The use of such a feed-heater obviously raised the centre of gravity of the locomotive by an appreciable amount. The service results were not considered to justify the upkeep and the first cost, which was somewhat heavy.

The apparatus devised by Ruzenzoff and applied to some 2,000 locomotives on the Russian Railways resembled the Halpin system to the extent that feed-water was contained in a drum housed over the boiler barrel and connected to the steam space. The economies claimed for this were upwards of 26 per cent. but it is difficult to see how these could be substantiated.

D. Drummond's feed-water heater was fitted to a number of locomotives on the London and South Western Railway. It consisted of a tubular heater, in the well of the tender, through which some of the exhaust was diverted. It also appeared on some 0-4-4 tank locomotives. Test reports were good and showed a reduction of some 6·3 lb. of coal consumed per mile.[40] In practice it had all the disadvantages of feed heaters of the period, i.e., complication, space, cost and especially weight. The condenser tank alone is reported to have turned the scale at about 1½ tons.

Serious trouble could arise with feed-heating equipment, when the water was bad. It was possible for a heater to be out of commission within a few hours of going into service due to bad water scaling it up almost solid, and in some parts of the world removal and cleaning about once a day would have been necessary.[41]

SUPERHEATERS

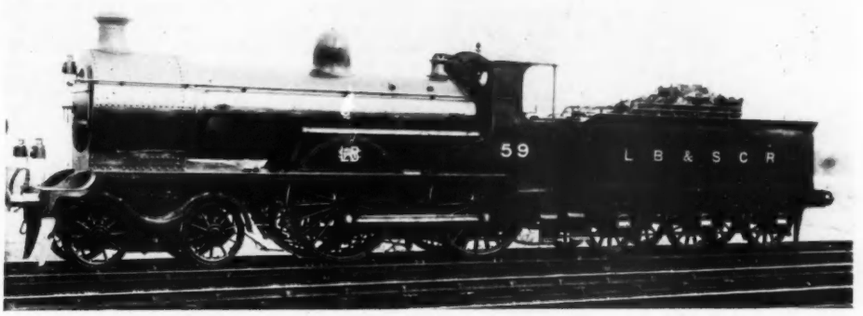
As fire-tube superheaters have been universally adopted with great success they do not qualify for inclusion in this series, which is devoted to ideas which did not come to stay. Before the fire-tube superheater was universally adopted, however, there were attempts to attain the same end by imparting heat to elements placed elsewhere.

The alternative situations were the boiler barrel, the smokebox and the firebox. The only superheater of the boiler barrel class to be used to any extent was the Pielock,[42] which was used by the Prussian State Railways and the Gothard lines. Briefly, this superheater may be described as a box, placed midway along the boiler, into the end walls of which the boiler tubes were fitted. It is perhaps unnecessary to point out that however efficient the device may have been as a means of adding to steam temperature, it was doomed to failure as there is nowhere on the locomotive more difficult of access for examination and repair. The Clench design was somewhat similar but close to the smokebox tubeplate; it had the same shortcomings as the Pielock.

Most of the early and elementary forms of superheater were housed in the smokebox. The Vauclain or Baldwin, of this type, had its main application in America, but was also tried experimentally on the Great Northern Railway. The Phoenix smokebox superheater was applied by several British railways on a very limited scale. It is not generally known that early Schmidt superheaters[43] were of the smokebox type. D. Drummond's "superheater," fitted in the smokebox of many L. and S.W.R. locomotives and a few engines on the G. and S.W.R., is more accurately described as a steam dryer, as the designer aimed only at attaining a temperature of from 10 to 20 deg. above saturation point.[44]

The firebox superheater was evolved by E. Cusack and Morton of the Midland Great Western Railway of Ireland, and applied to one locomotive on that railway.

Superheating is almost as old as the locomotive, having been used by Richard Trevithick in stationary practice as long ago as 1828. Its applications were numerous both on land and sea and its use was successful. It is therefore at first sight surprising that the use of superheated steam for the purposes mentioned was abandoned; one reason was that while pressures were low, lubrication presented no difficulties, but a rise in presure led to both lubrication problems and higher efficiency, as a result of which superheating was abandoned.



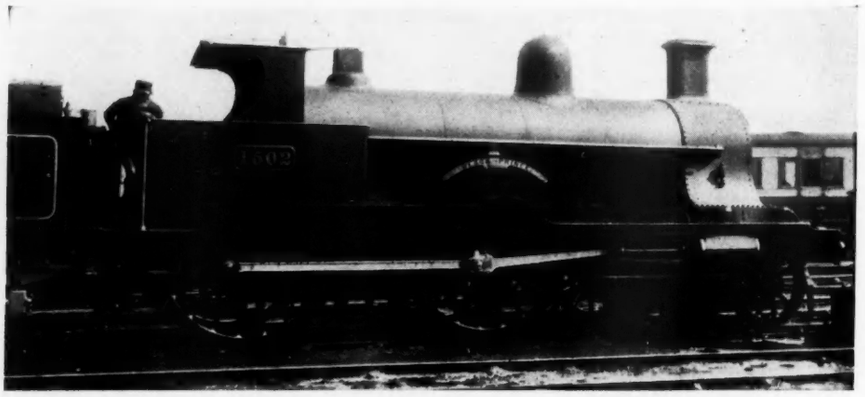
Locomotive with Phoenix smokebox superheater.

Locomotive superintendents adopted superheating to their own requirements. Sometimes it was hailed as a means of increasing cylinder sizes and hence power, at other times it was employed with reduced cylinder sizes to produce economy with the same power output as formerly and reduce boiler maintenance costs. When superheated steam was first used on German locomotives it was as a substitute for compounding,[45] and there was doubt even in the mind of such an eminent locomotive engineer as Edouard Sauvage that the proper course was to build superheated compounds rather than simple four-cylinder engines.

It was the practice to fit some compound locomotives with a second superheater—or reheater—between the high-pressure and low-pressure cylinders,[46] the object being to reduce the temperature of superheat in the h.p. cylinders. Though no trouble could ever arise from scale being deposited in the reheater, there was the likelihood of oil being carried over from the h.p. cylinders, which could be much more injurious. An experiment tried on the Eastern Railway of France was the use of a superheater for receiver steam only.

SMOKEBOX

There have been many attempts to improve blast arrangements, in the form of special blast-pipes, special chimneys, or partitioning of



L.N.W.R. four-cylinder compound locomotive with Webb's double chimney.

the smokebox. Variable-orifice blast pipes in the early years of the century had a fairly wide application.

In some, the area of the orifice was determined by raising or lowering a cone, the position being selected by a hand-operated control, and in others, e.g., the variable blast arrangements used on the G.N.R. and the L.T. & S.R., the opening was controlled by the rate of cut-off. The Macallan blast-pipe, used extensively on the G.E.R., gave the choice of two areas, a hinged cap being lowered over the orifice. The European variable orifice was variable within comparatively wide limits. The elliptical orifice had two hinged members on each side and was used in conjunction with a chimney of approximately square cross-section. Later developments, such as the Kylala, Le Maitre and Giesl blast-pipes, do not come within the scope of this article as they are used in current practice.

The inside of a smokebox is one of the worst places for maintaining moving parts in working order. It is not surprising, therefore, that variable blast arrangements were not perpetuated. Probably the most widely applied variable orifice was the G.W.R. jumper cap, but it has not been perpetuated owing to difficulty in keeping it working freely. Even when no moving parts were involved, as for example with the Adams "Vortex" blast-pipe, there still remained the difficulty of keeping steam passages free from carbon.

German locomotive engineers at one time held the view that the correct form for the blast-pipe orifice was a vena contracta, but so far as the writer is aware the only British locomotive superintendent to put this view into practice was W. F. Pettigrew of the Furness Railway. The use of several petticoat pipes, as in the Kylchap exhaust system, appears to have originated in the United States, and was employed by some of the Welsh railways.[47] Shapes of blast orifices have been legion, and have ranged from the common circular nozzle to the rectangular opening encountered in Belgian practice. Variants have been star-shaped, annular-ported, etc.

A rectangular blast orifice was fitted to L.N.W.R. "Experiment" class locomotive No. 2630. It was $6\frac{5}{8}$ in. by 4 in. and gave an area 7 sq. in. greater than the standard bush. The results were very unsatisfactory and a reduction to $6\frac{5}{8}$ in. by $3\frac{3}{4}$ in. effected a considerable improvement, but steaming was not good enough for heavy work and the standard blast-pipe was substituted.[48]

In Webb's application of a double chimney, which aimed at equalising the draught over the upper and lower tubes of his four-cylinder compound "Black Prince" (No. 1902), the smokebox was partitioned horizontally, the front chimney being connected to the lower part and the rear chimney to the upper half. In all recent double-chimney applications, some of which have produced most satisfactory results, the two chimneys have been mounted on a box common to two blast orifices, or in the case of the Giesl blast ejector the elliptical chimney has been above the multiple jets arranged fanwise on the longitudinal centre line of the smokebox.

Sir Nigel Gresley fitted an exhaust by-pass on 2-8-2 P2 class locomotive No. 2004 to reduce the blast, which had a tendency to lift the fire at starting or when working heavily at late cut-off.[49] A manually controlled butterfly valve gave a connection from the twin blast-pipes to a 5 in. diameter by-pass pipe having an aperture behind the chimney. A reduction of about $\frac{1}{2}$ in. in smokebox vacuum was obtained. Later, a plug valve was substituted, automatically controlled from the valve gear, and a $5\frac{1}{2}$ in. by-pass, breached into the double blast-pipe, was substituted. As modified, a reduction of 1 in. in the smokebox vacuum was obtained with the valve fully open at 40 per cent. cut-off. In both instances trouble was experienced with the valves due to their becoming clogged with carbonised oil.

To be continued

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Letters to the Editor

DEFLECTION OF FRAMES

Reduction Method Using Complementary Energy

SIR,—In order to find the vertical deflection v_p at any joint P of a statically indeterminate frame (Fig. 1) due to any system of loads (for example, a vertical load V at another joint, as shown) the system must first be analysed to find the forces in the members due to V. The next step consists of replacing the redundant members by the equivalent system of external forces as shown in Fig. 2 and applying an additional arbitrary vertical load Q at P. The total forces in the members of the statically determinate system can now be found by analysing this system with respect to Q and adding the forces in the members

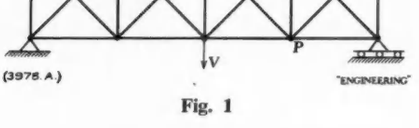

Fig. 1

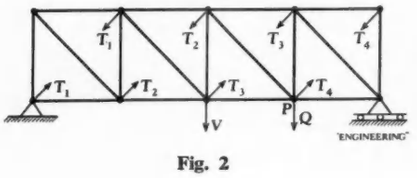

Fig. 2

so determined to the values obtained by the original analysis. Thus, for any member of the statically determinate system:—

$$T = a T_1 + b T_2 + c T_3 + d V + k Q$$
$$= K + k Q$$

where a, b, c, d, k and K are constants.

Variation of the complementary energy with respect to Q now gives:—

$$v_p \delta Q = \Sigma e \delta T$$

where the summation extends over the statically determinate system and e, the total change of length (l) of a member, is given, for example, by $\frac{T l}{A E}$ if Hooke's law is obeyed.

Therefore,

$$v_p \delta Q = \Sigma \frac{(K + k Q) l}{A E} k \delta Q.$$

But if $Q = 0$:—

$$v_p \delta Q = \delta Q \Sigma \frac{K l}{A E} k$$

or $$v_p = \Sigma \frac{K l}{A E} k$$

—a familiar type of result.

Although linearity has been introduced for convenience in illustrating the method, it is perfectly general so long as gross distortion of the structure under load is absent. It is interesting to compare this method with the reduction method for deflections using virtual work (ENGINEERING, vol. 180, page 139). This method is, of course, worth considering only when

analysis of the structure by obtaining equations of equilibrium in terms of displacements is less convenient than the alternative approach.

Yours faithfully,
T. M. CHARLTON.

Engineering Laboratory,
University of Cambridge,
Cambridge.
November 14, 1956.

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CORRECTING ORIFICE METERS

SIR, Mr. M. V. Nesbitt, in his article "Correcting Orifice Meters for Pulsating Flow" (ENGINEERING, July 27, 1956, page 108), has proposed a method of correcting the reading of an orifice which is measuring pulsating flow, by means of certain prescribed measurements of average and instantaneous pressures.

It appears to be necessary to indicate some reservations to this analysis. At a sufficiently low pulsation frequency, equation (1) of the article will apply. Likewise, at a low frequency, any standard measuring system can record the instantaneous absolute and differential pressures. Under these conditions, no important problems arise from the pulsations, other than the solution of equation (1). As the frequency of pulsation rises, however, a variety of phenomena become highly significant.

Mr. Nesbitt's assumption (2) cannot be valid any longer, for, while their frequencies may be the same, pulsations at various locations will have different wave shapes and will not be in phase. Also, equation (1), which is essentially the Bernoulli equation, becomes inapplicable, as pointed out in many investigations (such, for instance, as that referred to in Reference 1 of Mr. Nesbitt's article). Furthermore, it is unlikely that either the instantaneous coefficient of expansion or the Reynolds number correction can be represented by the formulae used for steady flow.

Also, Mr. Nesbitt's rejection of the significance of "acoustic effects" overlooks an essential point concerning this problem. The difficulty experienced in metering pulsating flows actually occurs when the acoustic effects are important, i.e., when the orifice configuration is presenting a complex non-linear impedance to the flow of gas. Under these conditions, the error produced is a much more complicated function of wave shape than the R.M.S. type of error considered by the article.

It may be of interest that, under the auspices of the American Gas Association, the Southwest Research Institute in San Antonio, Texas, is conducting a research project on the problem of metering pulsating flow. Their initial effort is directed towards determining the limits of pulsating conditions within which equation (1) applies to orifice flow (within usual orifice coefficient error), and the magnitude of the error produced by larger pulsations. The committee guiding this work recognises, as does Mr. Nesbitt, that the "secondary," or manometer system, is itself an important source of error; but this aspect will not be considered until an understanding is obtained of how the orifice itself behaves.

Yours truly,
R. L. CURL.

N.V. De Bataafsche Petroleum Maatschappij,
P.O. Box 162,
Carel van Bylandtlaan 30,
's-Gravenhage,
Holland.
October 16, 1956.

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COAL AS A RAW MATERIAL

SIR, I wonder if Mr. S. B. Bailey gave any thought to the economics involved before writing his letter of November 5, published on page 614 of your issue of November 16 ?

He should look at

(*a*) the very high initial cost of his proposal, and

(*b*) the extremely heavy maintenance and operating charges.

The figures he gives are infinitesimal compared with the contribution to fuel economy which the National Coal Board's new plant is already making. Much more rewarding would be a calculation showing the heat and useful chemicals lost throughout the country by the low efficiency of combustion of household coal.

Yours faithfully,
G. W. J. BRADLEY.

Baslow,
Derbyshire.
November 20, 1956.

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CIRCULAR FIREBOXES FOR LOCOMOTIVES

SIR, We have read with great interest Mr. C. R. H. Simpson's remarks on circular fireboxes in the article "The Experimental Spirit" which appeared on page 610 of your issue of November 16. As he correctly points out, the circular type of firebox has been widely used on small industrial-type locomotives and very many have been built by this company, some during the past few years.

Long experience with this type of firebox has shown that on industrial and plantation engines where a high steaming rate is not called for, the disadvantage of poor water circulation is more than offset by the reduced capital and maintenance costs, and the ease of replacement of the box. While we have not seen icicles under the firebox—as stated by your contributor—we have found it quite possible to put one's hand on the underside of the unlagged boiler while this was being steamed at full working pressure in the shops.

It was the practice of this company to fit an internal water circulating device to boilers of this type, but there was no evidence that they improved the circulation to any noticeable extent and none have been fitted since the war.

Yours faithfully,
W. A. SMYTH,
Managing Director.

W. G. Bagnall, Limited,
Castle Engine Works,
Stafford.
November 20, 1956.

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COST OF LABOUR TURNOVER

SIR, On page 608 of your issue of November 9, you report briefly a paper presented by Mr. Webster, of Hoover Limited, illustrating the cost of labour turnover in the industry of to-day. The facts reported in your review are well known to all up-to-date managements. They are much deplored, and the cost of this phenomenon is fully realised and regretted.

It would be of great help to know whether Mr. Webster is able to propound any remedy for these disturbing conditions.

Yours faithfully,
D. S. PRINCE.
Managing Director.

Ronald Trist and Company, Limited,
Bath Road,
Slough, Buckinghamshire.
November 26, 1956.

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The first major contract for work on the St. Lawrence Seaway to be awarded to a British firm has been given to Russel Construction Limited, of Toronto, a wholly owned subsidiary of Balfour, Beatty and Company, Limited, of London. Valued at 7,280,000 dols. (£2,570,000), the work is connected with dredging in the Welland Ship Canal, joining Lake Erie and Lake Ontario.

Weekly Survey

Cover Picture: *Oval turning requires lathes with a special equipment that moves the saddle transversely as the work revolves. That this operation can be applied to the machining of both large and small products is shown in our illustration, which depicts the machining of an oval manhole in a solid drawn seamless steel boiler drum.*

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Loans from the International Bank

The annual reports of the International Bank for Reconstruction and Development are a valuable guide to the market for capital goods. The report for the year ending June 30, 1956, shows that 26 new loans were made totalling 396 million dols. Loans for the development of electric power again led with a total of 148 million dols., with transport second at 127 million dols. Since the Bank's foundation, 40 per cent. of its loans have been for power and 30 per cent. for transport. An increasing proportion of loans are going to Asian countries, the total for last year amounting to more than two-fifths.

One of the largest loans negotiated during the year was that of 80 million dols. for the Kariba power project. In view of the criticism of the Federal Power Board for not placing its main civil engineering contracts with British contractors, it is interesting to note that the Bank is charging the Board 5 per cent. for its loan and is understood to be willing to reduce this if the instalments can be resold at a lower rate as they are called forward; while the Colonial Development Corporation is forced to charge over 6 per cent.

A depressing trend is disclosed by the table showing where the heavy equipment which is mainly financed by the bank was bought. Since 1954 the value bought in the U.K. has fallen from 54·9 million dols (21·7 per cent.) to 30·0 million dols. (13·2 per cent.) while that bought in Germany rose from 22·9 million dols. (9·0 per cent.) to 32·0 million dols. (14·1 per cent.). The United States share remains at just over 50 per cent.

The operations of the Economic Development Institute, announced last year, commenced with a six months' comprehensive course for economic administrators from less developed countries. It is hoped to use this new kind of international staff college to overcome the waste of effort and resources which often results from the shortage of trained and experienced administrators.

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Australia's Aeronautical Contribution to the Commonwealth

Australia, one of the two most air-minded nations in the world, is ideally suited, by reason of her climate, topography and highly-developed ground facilities, for the intensive flying of aircraft. Although Australia already offers a large contribution to aeronautical research for the Commonwealth, she could probably contribute still more to aeronautical progress if her natural resources were more fully appreciated and utilised by the rest of the Commonwealth. This, probably, is the most important conclusion to be drawn from the Twelfth British Commonwealth and Empire lecture, on "Aeronautical Development in Australia and its Potential Contributions to the British Commonwealth," given before the Royal Aeronautical Society recently by Mr. L. P. Coombes, Chief Superintendent of the Aeronautical Research Laboratories, Melbourne.

The favourable desert conditions at the Woomera rocket range and the engineering facilities of its supporting base at Salisbury—an excellent example of the co-operation between the United Kingdom and Australia—have led many British weapons manufacturers to set up

satellite factories in Australia. It is Mr. Coombes' contention, however, that the makers of commercial aircraft could also profit from Australia's natural advantages, and that Australia offers exceptional possibilities for cutting down the lengthy development period required to bring an airliner to function. Why, he asks, cannot British manufacturers put new airliners, quite early in their development, into service with the Australian airlines who, "by reason of their wonderfully suitable conditions of operation, have higher utilisations of aircraft than any other country in the world"? By this means, the weaknesses are likely to be revealed much earlier; possibly some three years could thus be saved. Mr. Coombes suggests also that British manufacturers might well avail themselves of the wide experience, under highly competitive conditions, of Australian operators, in the specification and conception stages of projected design. This might ensure the acceptance of new aircraft types in a much wider market than the European.

The success of the Australian airlines is attributed by Mr. Coombes, not only to Australian natural resources and city distributions, but also to the enterprise of the operators and the fact that unrestricted competition is allowed between the operators on domestic routes, which forces them to be progressive in their choice of equipment. Here also is another thought for aviation administrators to ponder on.

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Dowty Nucleonics

When the Dowty Group acquired the Cheltenham firm Davis, Wynn and Andrews, Limited, a little more than a year ago, the principal interest of the latter firm was in radioactive dosemeters for civil defence. With their absorption into Dowty, to form the basis of the latest of the group's subsidiaries, Dowty Nucleonics Limited, with Mr. T. D. H. Andrews of the original company as managing director, these interests have been considerably widened. The company have now entered the fields of nucleonics, servo-systems, and electronics. Recently all work on aircraft electrical equipment, including production facilities, was transferred from Dowty Equipment; these production facilities are now being extended to cover the new company's other activities.

The main objective of Dowty Nucleonics now is the development of large-scale special-purpose instrumentation for nuclear reactors, which may involve a combination of mechanical and electrical engineering to which the Dowty Group as a whole can bring a useful background of experience ranging, as they do, from precision aircraft components to heavy industrial and coal-mining equipment. The company are already engaged in some interesting projects in this category, but are not yet in a position to disclose their nature. A physics laboratory has been set up to cater for the basic aspects of radiation detection. Following the dosemeter charger activities of Davis, Wynn and Andrews, the physics laboratory are also developing a new type of charging unit based on a Zamboni Pile.

The servo systems activities, still in the early development stages, range over a wide field from magnetic amplifiers for ionisation chambers to aircraft jet-pipe temperature control units (in conjunction with Dowty Fuel Systems Limited), and three-dimensional copy machining, based on a servo-operated hydraulic system (in conjunction with Dowty Equipment Limited).

The electrical division, also, ranges beyond the nucleonic field and, in fact, their present activities are mainly directed to making reliable precision electrical components—relays, limit switches, micro-switches, remote control systems and indicators—for industry generally, based upon their long experience of aircraft electrical components which must work to a guaranteed life under close limits. But whereas the aircraft user is satisfied with maybe 10,000 repetitions, the components intended for industrial use are designed for up to 1,000,000 repetitions.

Finally, the electronics division is also, at present, catering for industry generally, including nucleonic applications, with pulse-generating laboratory instruments, industrial counters and tachometers, some of which, described on page 690 in this issue, are based on interesting transistor applications.

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The Outlook for Cables

Important overseas contracts recently placed with British cable manufacturers offer good prospects for a continuation of the rapid increase in the production of cables which has taken place over the last two years. The total output of insulated wire and cables in 1955 was valued at approximately £124 million, an increase of 30 per cent. compared with the previous year. This figure compares with a previous peak production of about £119 million in 1952. Allowing for the increase in prices which took place between 1952 and 1955, it is probable that the volume of production in the latter year was still below that for 1952. A further increase of 30 per cent. in the value of production, however, took place in the first seven months of 1956 and it seems probable that the current volume of output is now at the highest level ever recorded.

About 25 per cent. of total production is exported, and after falling by about one-third between 1952 and 1954 the value of exports increased by 33 per cent. in 1955 to £30 million. In the first seven months of 1956 a further increase of 33 per cent. took place to nearly £20 million, a figure which is only slightly below the value of exports for the whole of 1954. This increase in exports has been achieved in spite of very strong foreign competition to which attention was drawn by the chairman of British Insulated Callender's Cables, Limited, at the annual general meeting of the company in May last.

At the beginning of this month, Standard Telephones and Cables, Limited, received a contract valued at £2·3 million for the supply and erection of co-axial cable in Portugal. The Kariba hydro-electric scheme has also given rise to substantial orders for cables, the total value of orders received by B.I.C.C. from this source being about £3½ million. A supplementary order valued at £200,000 for 330,000 volt cables to connect the underground powerhouse to the overhead transmission lines was announced last week.

In the home market Scottish Cables last week received a contract, valued at about £1 million, from the South of Scotland Electricity Board for the supply of paper-insulated cables in connection with the extension of the Board's distribution network.

Some anxiety has been expressed by cable manufacturers regarding the recent wide fluctuations in the price of copper and the danger of an impairment of their competitive position due to general rises in manufacturing costs. Provided this can be avoided, however, there appears little doubt that an exceptionally high level of production is likely to be maintained.

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Investigation into Capital Equipment

Results so far obtained from an inquiry into industrial capital by the National Institute of Economic and Social Research were given in a paper last week by Dr. Barna. The investigation is limited to manufacturing industry and covers only the cost of replacing existing assets with new assets. That is to say, it does not take account of technical improvements in new machines to any measurable extent. Although the findings are provisional as yet and they will probably be liable to a fairly large margin of error even when completed, they have nevertheless produced some interesting conclusions and are a further notable stride forward in the attempt to relate industrial output to investment in new equipment.

The total fixed assets in manufacturing industry, excluding the Atomic Energy Authority establishments, were estimated to be £15,100 million at replacement cost in the middle of 1955. This is much in excess of the last estimate of this kind made which, being based on Inland Revenue depreciation allowances, would tend to be on the low side in any case. Of this total, metal manufacturing, general engineering, and vehicles account for about £5,500 million or approximately one-third of the total. The rate of gross fixed-capital formation in manufacturing industry is estimated to be running at a record level in 1956, amounting to nearly 5 per cent. of the existing stock of assets. The largest percentage additions are occurring in paper, printing, chemicals and transportation-equipment industries. About 27 per cent. of the existing stock of fixed assets is estimated to be less than 7½ years old. The survey reveals a striking variation in the amount of capital employed per operative. At the one extreme is pottery with fixed capital, per employee, at £620 and at the other is oil refining with a figure of £13,350. The average figure is between £1,000 and £2,000 per head. One of the most interesting conclusions reached so far is that the average ratio of fixed assets to net output is about 3 to 1, but to obtain an extra £1 of output from a fixed labour force, £5 of equipment are necessary. This conclusion, admittedly probably a first approximation only, shows the extra investment which is necessary to get a small increase in output if the labour force is fixed and when technical improvements are ignored. These figures thus point at the importance of obtaining higher productivity by technical innovation with the existing labour force, once full employment is reached.

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Large Companies and Capital Scarcity

Electric and Musical Industries Limited, whose full accounts and chairman's statement became available last week, is an interesting example of how the dearth of capital can afflict even major manufacturing groups. In the year to June 30, 1956, the turnover of this group rose to the record level of £53 million. That advance was achieved in spite of a decline in the industry's sale of television sets and sound-radio equipment in the United Kingdom during the period between October, 1955, and June last. The main reason for this achievement is to be found in the fact that 60 per cent. of the group's turnover is accounted for by its subsidiaries in 24 different countries, nine of which have annual sales amounting to £1 million or above. Both at home and abroad, sales of records have increased and the turnover of Capitol records in the United States has been particularly impressive. The sales of domestic electrical appliances went up over the year and so did those of dictating machines, magnetic-recording-tape and electronic equipment. It would thus appear that the group's policy of continuing to spread its interests is being justified. The next test will be for the management, under its new chairman, to secure stability of performance in each of the group's many avenues of activity.

It is apparent, however, that this impressive performance in the last financial year has put a heavy strain on the company's financial resources. The bank overdraft has increased substantially and Mr. J. F. Lockwood, the incoming chairman, has estimated that the year's profits before tax were only 4½ per cent. of the group's turnover, which, for a concern of this size and diversification, amounts to trading on a shoe string. This is but one instance of a growing problem. It is becoming increasingly difficult for industry to attract the capital it

needs when it is operating on terms such as those now ruling. For, although it is not the same thing, a small profit margin on turnover must mean, in most cases, a small profit on the capital employed. The fact is that the terms on which industry can now attract new capital are, thanks to heavy taxation and rising costs, especially unattractive, just when the need for new funds is most urgent in the interests of both industry and the nation.

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Copper's Contribution to Central African Development

The economic development of the Federation of Rhodesia and Nyasaland is largely dependent on the development and profitability of existing primary industries, mainly copper mining and agriculture, and the rapid rate of progress achieved owes much to the high level of copper prices up to the end of 1955. Sir Ronald Prain recently drew attention to the fact that profits of the Selection Trust group of companies are likely to show a substantial reduction in the current year as a result of the fall in the price of copper.

In his statement to be read at the annual general meeting of Rhodesian Anglo-American, Limited, to be held in Salisbury on December 13, Sir Ernest Oppenheimer draws attention to the substantial contribution to the general development of the Federation which is being made by the copper mining companies. In addition to taxation on the profits of the companies, which is estimated to amount to £27,500,000 in the current year, the companies are providing a loan of £20 million towards the £113 million required for the Kariba hydro-electric scheme. They will indirectly provide a further £10 million as the result of an agreement to accept power from Kariba for some years at a price higher than is required to cover operating costs.

One of the great needs of the Federation at the present time is an improvement in transport facilities since congestion on the railways is a factor affecting the establishment of new factories and is understood to have been an important consideration in planning the expansion of the steel industry near Que Que. Sir Ernest Oppenheimer stated that the Wankie Colliery Company is now equipped to produce 5 million tons of coal per annum; and that 1 million tons a year could be exported if railway transport was available. The Anglo-American group is therefore assisting the railways with a loan of £1 million, and has provided £5 million for the purchase of trucks which it will hire to the railways.

These sums are very considerable, particularly since they are additional to the very large amounts necessary to develop the copper industry itself. Sir Ernest pointed out that £18 million will have been spent on development of the Bancroft Mine by the time the first ton of copper is produced while further mining developments planned, including expansion by Mufulira Copper Mines, Limited, and the intended operation of Chambishi Mines, will require the companies to find some £50 million by the end of 1960. The trend of copper prices over the next few years must therefore exert a very important influence on the whole economic development of the Federation.

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The Aircraft Corporations Bill

Attention was drawn in Parliament last week to the high cost of modern civil airliners when the Aircraft Corporations Bill received an unopposed second reading. The Bill raises the borrowing powers of B.O.A.C. from £80 million to £160 million and those of B.E.A. from £35 million to £60 million. It also gives permission to B.O.A.C. to borrow from the International Bank for Reconstruction and Development, or from the Export-Import Bank.

The two Corporations have on order 33 Britannias, 22 Comets and 14 Viscounts, but so far as B.O.A.C. are concerned the increased borrowing powers are primarily required for the 15 Boeing 707 aircraft recently ordered and for a substantial number of DH 118's. It was stated that the combined cost of these new aircraft was expected to be about £100 million. It has already been announced that the Boeings will cost £44 million and it therefore appears that B.O.A.C. expect to spend about £56 million on the DH 118. No official announcement is likely to be made, however, until the design of the latter is much further advanced. B.E.A. are expected to place orders during the next five years for helicopters and possibly also a small number of jet aircraft for the longer routes.

The power granted to B.O.A.C. to borrow from the International Bank or from the Export-Import Bank is intended to help in the provision of dollars for the purchase of the Boeing airliners. It is hoped that it may be possible to dispose of 12 Constellations and eight Stratocruisers, which were bought to replace the Comet, in part exchange against the Boeings, but even so a substantial dollar expenditure is likely to be required before the new aircraft start earning dollars. With the present drain on the country's gold and dollar reserve it may be found expedient to borrow this amount. If all capital needs of B.O.A.C., including buildings and equipment, are taken into account their total capital expenditure is estimated at £200 million. Internal financing is, however, expected to reduce the net requirements below the figure of £160 million provided for in the Bill.

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The Swiss on the Wagon

A railway goods truck has a normal life of 35 to 40 years. About 42 per cent. of all the wagons in Europe have now reached that age. This state of affairs makes the renewal of Europe's railway rolling stock a big financial headache. Competition from the roads is now so keen that few of the nationalised railways earn profits on a scale that will pay for new coaches and trucks.

In 1953, ten western European countries formed a pool of 160,000 wagons for use throughout their national areas. This plan—"Europagreement"—cut out the necessity for returning empty wagons to their country of origin. As a result of the work of a study group meeting in Paris, a plan for the joint purchase of new rolling stock has been evolved. Fourteen European countries have agreed to form a joint stock company called Eurofirma with headquarters at Basle. The primary object is to renew the 160,000 wagons in the Europagreement pool. As a new truck costs about £2,400, replacement at the rate of 4,000 a year will require some £9½ million. Even at that rate it would need 40 years to renew the whole pool. It is hoped that with Swiss capital it will be possible to improve on this rate.

The capital of the new company will be 50 million Swiss francs. Shares will be of two kinds—"A" shares in cash and "B" shares in the form of trucks for common use. The scheme will begin with Eurafirma renting to Germany, France, Italy, Belgium and Holland the trucks represented by their "B" shares. The yearly rental plus an amortisation charge will enable them to be written off in ten years. A maximum of 4 per cent. has been set for dividends. For a start, Eurofirma will use its own cash resources of 12½ million Swiss francs to cover orders for new trucks. As the scheme develops it is estimated that some 100 million Swiss francs a year will be invested. Eurofirma has no monopoly, but as few of the member countries have any cash to invest in wagons the company will be in a very strong position. Eurofirma looks like being another step towards the economic integration of Europe.

Motor Vehicles at the Cross-Roads

Four of the big firms in the motor industry, British Motor Corporation, Joseph Lucas, Standard Motor Company and the Rover Company, published their full reports and accounts earlier this week. Perhaps the most concise statement of the industry's future prospects was made by Mr. H. Howe Graham, chairman of Rover, who said: "I can only utter a word of warning that times immediately ahead are going to be difficult." But this was written without reference to Suez and petrol rationing; it referred mainly to increasing competition and restrictions abroad and to the threat of further wage demands at home. Since then the Ford Motor Company have announced that it may not be possible to maintain full employment during the fuel crisis and that, for the first time this year, some of their employees may have to be put on a four-day week. Rootes anticipate they will be working a short week from this week onwards and that some workers will be dismissed. Vauxhall, who are already working short time to adjust output to the seasonal fall in demand, now expect this to extend beyond Christmas.

Sir Leonard Lord, chairman of B.M.C., foresees difficult trading conditions for another 12 to 18 months but is confident of a long-term demand for the industry's products: "Even though for the time being we are prevented from making the fullest use of the improved production facilities, I have no doubt as to the wisdom of providing them . . . what we are now spending can be considered as a premium necessary to insure the future." B.M.C's development programme involved an expenditure of over £9 million in the year to July 31, and there are further commitments of nearly £7 million. Despite all difficulties encountered during the year under review, output was 5 per cent. greater than the previous year and Sir Leonard sees "signs in some markets" of the restrictions easing and of demand becoming freer. Standard suffered a cut of 19½ per cent. in car output and of 25½ per cent. in tractor output. Their chairman, Lord Tedder, suggests that an improvement is likely in tractor production to follow the extensive re-tooling which started all the trouble over redundancy in Coventry. "Maximum production" is likely to be reached this year and the demand for cars is said to be reviving.

Lucas, who are soon to be involved in an inquiry by the Monopolies Commission on "the supply of certain electrical equipment for motor vehicles," fare rather better than any of the car manufacturers. Profits fell by just over 30 per cent., compared with a fall of nearly 50 per cent. for B.M.C. and 77 per cent. for Standard. But the importance of the trade in spares, the high output of heavy commercial vehicles and good demand for aircraft electrical components all helped to offset the severe trading losses incurred when motor manufacturers cut back their output schedules.

These results will lead to criticism of the industry's determination to carry through their expansion plans irrespective of present-day conditions. Yet if the rate of growth in the expansion of the world's vehicle population is maintained during the next 10 years—and there are no very obvious reasons why it should suddenly change—then it is of the utmost importance that the industry should press forward with its plans for modernisation and expansion. To fail to do this would be to invite defeat on world markets. In the short-term the car manufacturers' prospects are not good. There is little or no likelihood of any relaxation of the Government's restrictions on the home market, whether of hire purchase or of credit generally. The future of the industry is inescapably tied to its ability to sell large numbers of vehicles overseas. This is all the harder to achieve if home sales are restricted, since low costs depend on large scale, full-capacity production. Nevertheless, this must be done if the industry's expansion plans are to be justified from the nation's point of view.

REMEDIES FOR LOST ENERGY

The sudden and drastic cut in oil supplies, following our intervention in Egypt, has brought into sharp relief the picture of our dependence on sources of energy. As a result, every possible alternative to our present dependence on supplies of oil through the Suez Canal, and even on oil itself, is being canvassed. These are chiefly the building of super-tankers, the enlarging of the atomic energy programme and the abandonment of the plans for railway Dieselisation; although, significantly, little is heard of the possibility of raising production of our main indigenous resource—coal.

None of these suggestions could in any way help with the problem of the next two or three years during which we shall have to face first a shortage and then, undoubtedly, a higher price of oil. It is unlikely that the Canal will be completely free and able to take ships of the larger size for at least six months and we must therefore face a shortage of oil supplies of at least 20 per cent. for that period or longer. Although this represents only a 2 per cent. cut in total fuel supplies to industry it is a cut concentrated in certain vital parts of it and when the effects on transport and particularly shipping are considered, the disruption it will cause is likely to be far greater.

It is during this period, however, that the first steps in construction needed to ensure that, as far as possible, we are never again put in this precarious position must be taken. It is obvious that none of them can deal with the immediate situation or even be effective at all for some years; but in the meantime they are likely to be strong competitors for scarce resources and, therefore, their timing and the priority they are accorded over other capital investment projects need careful consideration.

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Super-Tankers

Proposals for the use of very large tankers were already being considered before the present situation arose and are based on their economy in building and operating costs. As long as the Canal was under responsible management tanker operators considered 40,000 tons deadweight as a reasonable size for the transport of Middle East oil to Western Europe; but this was dependent on adequate and continuous maintenance and improvement of the Canal. Now that the reliability of the Canal management cannot be foreseen, attention is being directed to tankers capable of bringing oil economically round the Cape, and this necessitates a jump in size to at least 60,000 tons. In view of the fact that building costs per ton decline as size rises and power requirements, and therefore fuel consumption, increase only moderately (a 45,000 ton vessel consumes only 28 per cent. more fuel than one of 32,000 tons) there is a strong case for going further; at least, to the point where a single screw would have to be replaced by twin screws with higher machinery and operating costs. This occurs at around 90,000 tons deadweight.

There are serious difficulties in building any substantial fleet of tankers of this size in the next five years. The shipbuilding industry has a full order book and is hampered by steel shortage and labour problems; but in any case there are at present no berths capable of handling the largest vessels and there are difficulties about constructing them in existing yards; although one yard on the North-East Coast is expected to be able to handle at least one 100,000 tonner when its current plans are completed.

Harbours for these giants do not at present exist, although by dredging three of the main oil terminals can be made to accommodate them.

On the Severn and the Mersey it will be necessary to build new terminals and pipelines at heavy expense. Finally, there is the question of repair facilities. There are no dry docks in this country capable of handling the larger sizes already contemplated and a substantial dry dock building programme will be needed as well as enlarged quays and bigger repair shops equipped with heavier machinery. All this adds up to a very large construction programme involving manufacturing and financial resources on a considerable scale for which there can be no return until the early sixties.

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Atomic Energy

The original nuclear power programme envisaged the production of electricity equivalent to that of 40 million tons of coal by 1975. There is little doubt that this will be improved on and suggestions are now heard for doubling the programme immediately. Unless the Atomic Energy Authority and the Central Electricity Authority were given overwhelming priority in supplies of material and scarce manpower this is certainly not a possibility. Even if it were, the advantages of doing it must be set against the losses that would be sustained in other sections of industry with which it would compete for resources.

Present estimates indicate a contribution by 1965 of 5 million tons of coal equivalent from nuclear energy compared with 66 million tons from oil. Even a doubling of the nuclear output during the next ten years will only reduce our oil needs by 7½ per cent. and, barring an unlikely jump in coal production, we must continue to base our immediate policy on the safeguarding of oil supplies.

The nuclear energy programme is in direct competition with the tanker programme for some things of which we are very short. Constructional steel and heavy steel plate are the most obvious; but design engineers, draughtsmen and skilled craftsmen are also likely to be as important. In this they are both in competition with other parts of the country's capital investment programme and with the industries manufacturing capital goods for export, on which, with the reduction of consumer goods and oil products exports, we must in the future increasingly depend. The deterioration of our balance of payments arising from the blocking of the canal makes the maintenance of the total value of our exports more important than ever.

Perhaps the most serious difficulty the Atomic Energy Authority and its suppliers will face in expanding its programme is the shortage of qualified scientists and engineers. The White Paper on Scientific and Engineering Man-power in Great Britain " arbitrarily " put their requirements of these classes during the next three years at just over seven hundred, which is probably on the conservative side.

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Steel

The cut in oil supplies following after this year's overtime ban by maintenance men will prevent the steel industry reaching its target of 21·3 million tons and it seems inevitable that there must be a fall in output of crude steel next year. This need not effect the construction programme discussed in the previous notes if it were possible to shift the output between particular qualities.

The weekly consumption of the motor-car industry fell in July to 19,100 tons and in August to 15,600 tons a month from the year's average of 24,300 tons; a drop that is more than can be accounted for by holidays and one likely to be accentuated in the coming year. A large part of this consumption however is light forgings and sheet. Supplies of heavy sections and bars might be increased by restrictions on new industrial and commercial building which have been consuming at the rate of 20,800 tons a week this year, or by increasing imports, although these have already been running at the record rate of 5,000 tons a week.

The main bottle-neck, which has existed almost continuously since the end of the war, is in heavy plates for the supplies of which the shipbuilders and the nuclear power station builders are competitors. In particular larger tankers and nuclear plants will require increasing quantities of the heavier thicknesses. Production of all sizes over 3 mm. thick has been rising very slowly and has averaged this year 47,600 tons a week. A cut in exports now at under 10 per cent. of output could contribute something; but it is unlikely that current imports of the same order could be much increased. The only real solution is the construction of a new plate mill which must take a considerable time.

Meanwhile some delay may be necessary in the plans of other users of heavy plate, such as the railways and the petroleum industry for refineries, in order that priority may be given to the immediately urgent need to safeguard our energy supplies as rapidly as possible and to maintain our exports.

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Salvage Work

Behind the political turmoil surrounding the Suez Canal operations, the combined British and French salvage force has gone ahead with forcing a channel through Port Said and into the canal itself. By Sunday evening a channel 180 ft. wide and suitable for ships of 10,000 gross tons had already been cleared from the entrance to Port Said and down the canal to the limit of the Anglo-French zone at El Cap. Though such vessels would have to zig-zag between the remaining wrecks, this channel will probably allow all but one of the 13 trapped merchantmen to be released into the Mediterranean. Of these vessels, nearly all of which were in the western branch of the El Ballah cut, three are just over 10,000 tons (the Italian ships Emma, Americano and Amalfi) but it should be possible to get them out; the largest vessel—the Liberian Statue of Liberty of 22,610 tons—looks unlikely to be freed for some weeks.

Messages from the area indicate that the first of the block ships to be raised was the hopper Triton, which was the most westerly of three vessels sunk across the channel just inside the Central Mole and of which the centre one, the 3,000 ton suction dredger the Paul Solente, was the most effective of the blockships. She was originally reported to have been sunk by eight holes blown in her hull which were said to have been patched a week ago, but one message described it as " at least a month " before she could be salvaged.

The cleared channel is sufficient to allow the whole of the salvage fleet to get right into the harbour and among the wrecks. By November 30 this fleet will have been augmented by 28 vessels, bringing the total up to 46—probably the largest salvage force mobilised since the end of the war. Apart from any limitations imposed by political issues, this force should be able to clear away the wrecks to allow the transit of perhaps 80 or 90 per cent. of the vessels using the canal. There will still remain, however, the problem mentioned in our last week's article " Clearing the Suez Canal ": that of dredging the canal so that the biggest vessels can move at a reasonable speed. It is not going to be sufficient that they do not scrape the bottom. Full operation of the canal will still require the replacement—from one source or another—of the dredgers, hoppers, tugs and other maintenance vessels.

ORGANISING FOR RESEARCH

2—CREATING THE RIGHT STAFF

By E. I. Brimelow, M.ENG.

The second of a short series of articles reviewing the recent conference on the "Direction of Research Establishments," held at the National Physical Laboratory, Teddington. The author is industrial and scientific liaison officer at the Laboratory. The first article appeared in ENGINEERING, *November* 16, 1956, *page* 617.

A good understanding of the characteristics which go to make up the various groups of research workers with which those in charge are concerned is a fundamental requirement of all successful administration. Professor D. J. van Lennep,[1]* Professor of Psychology, State University of Utrecht, reported to the conference on research which had been going on in the Netherlands to enable management to use scientific people in the most efficient way. He said that he had tried, in his paper, to answer the question of what kinds of people were needed in a research laboratory to enable it to fulfil its function, and then to consider how these people could best be used for their various tasks. Professor van Lennep thought it was a false notion that a large research laboratory should engage exclusively very creative people because for the work to be progressed successfully there must be a large staff with other characteristics.

Conditions for Creative Work

For the purpose of his study, he divided research workers into three main groups, each having its own special characteristics. First, there were men possessing a "need of achievement," that is, a variety of characteristics which together enabled them to solve problems, which had been clearly formulated and identified by the management, by applying existing and generally orthodox methods. A characteristic of such research workers was that they did not abandon their problems until, by systematic work, they had brought them to a successful conclusion. Secondly, there were men with a "problem solving ability"; this term being used to describe a combination of qualities found in research workers who were capable of solving problems which had been exactly and clearly formulated by the management, largely by original and unorthodox methods. Such men were capable of solving problems for which a satisfactory solution could not be found by the usual methods. Research investigators of this type, as was to be expected, were usually very swift and flexible thinkers, and were able to survey data on a given problem at a glance. Thirdly, there were those to whom the description "creativity" could be applied: this term being used to describe those qualities which enabled research workers to give form and substance to problems which either had not been formulated by the management at all, or else, had been set out only vaguely. Staff of this calibre were capable of taking such problems, reformulating them, and solving them in an original manner, or, at least, of indicating ways by which they might be solved. Research workers in this category usually excelled in the vast richness of their ideas, many of which would appear to be quite practicable.

From the results of his experiments with groups of creative and less-creative chemists and physicists, Professor van Lennep concluded that the creative group differed significantly from the less creative group in the following main aspects: they were less dependent upon their environments; less rigid and less dogmatic; and had a characteristic time perspective—that is, they perceived the future, not as a mere repetition of the past, or as being completely independent of them, but as fraught with possibilities which they themselves could help to bring about.

Professor Morris I. Stein,[5] University of Chicago, U.S.A., reported, in his paper, on the results of research on the problem of creativity with respect to industrial research chemists. His survey, he stated, was designed to investigate both the sociological and psychological factors related to creativity. He regarded creativity as being the result of social environment and of processes occurring within the individual. In industry, the scientist had several roles to fulfil: the scientific, the professional, the social, and as an employee. Each of these roles made its own special demands. How, he wondered, did environment react on a man's ability to be creative; and, providing the environment was satisfactory, what psychological factors provided an impetus to creativity ?

Professor Bernal, in his paper, previously mentioned, commented that the inventive faculty was as necessary to-day as ever, but that the nature of modern industry made it increasingly difficult for this faculty to be exercised by independent individuals. He pointed out, too, that the history of invention had shown that actual success depended not only on originality and imagination, but on knowing what to invent; that is, a good knowledge of the field of requirements, of the possibilities of the market, and of costs and prices. Even if the inventor could obtain this information, before the invention could reach a prototype stage, it required development facilities which no individual could command. These comments lead to a consideration of the group approach to research, and Dr. J. Bronowski, director, Central Research Establishment, National Coal Board, made the point that, in this country, great difficulties were encountered because specialisation in scientific education was encouraged so much more and so much earlier than was the case in Russia and the United States.

Encouraging Enthusiasm

Professor Herbert A. Shepard, Massachusetts Institute of Technology, pointed out that what he called "horizontal" team-work had been invented originally in this country, but that it was now more widely practised in America than here. In Britain, team-work was falling behind, because, in order to be able to work in a team which included many specialists, a man must have a wide general grasp, beyond his speciality, of what the other men in the team were doing. It was just not possible to organise such a team of equals if they were all no more than specialists.

The papers by Professor Shepard[6] and by Sir Charles R. Harington,[7] director, National Institute of Medical Research, were concerned with the basic problems of organising scientists in such a way that, on one hand, they worked well, and, on the other, that they did the work which they were asked to do. Professor Shepard emphasised the fact that all organisations tended to be run on military lines. By temperament, by habit and by outlook, he said, the scientist was particularly resistant to that kind of marshalling. In the ensuing discussion reference was made to the creativity of scientists in developing methods of resistance to authority.

Sir Charles Harington contended that, in essence, an establishment should be organised on a basis of mutual confidence, with authority kept very much in the background, and with counsel and advice readily available. There should be the minimum of formal rules and the maximum of intellectual freedom and intercommunication, so that the whole organisation was held together by a sense of purpose, thereby leading to a conviction that it was well worth while to work for the objects of the organisation.

Mr. P. E. Trier, Mullard Research Laboratory, in discussing this paper, made the suggestion that it was not so important in laboratories for the head of the department to be a distinguished scientist, but rather that he should have another talent, namely, that of acting as an interpreter of policy decisions to his own staff in a human and personal way.

In summing up this session, Dr. Bronowski said it appeared to be that the universal concern was to get the best out of the staff. This reminded him of a remark to the effect that the most important product of the mine was the miner; and so one might argue that the most important product of the laboratory was the young research worker: he was our investment for the future.

Considering the Older Scientist

Arising from the discussion, it transpired that one of the more serious problems some directors of research had to face was what to do with the older scientist, or, as one delegate expressed the difficulty, how to deal with the older man who was no longer a leader—the "one-time leader who had lost his fire." Another speaker referred to these older scientists as men who were no longer receptive to new ideas, and who had often become resentful to them. The limiting age for creative work was considered to vary; in mathematics, as early as the age of 25 was suggested, while, in the physical sciences, the limit was not considered to be reached before the age of 40.

Sir Charles Harington emphasised the need to provide an environment in which a man could develop from the young inventor to the powerful thinker, that is, into the mature man who evolved original ideas, in which process his one-time inventiveness could be wedded to his growing experience. Specialists, in particular, found this period of transition especially difficult, and Sir Charles considered that outside, non-scientific interests could be helpful in helping to solve these problems.

In industry, there were more outlets and opportunities for men to move on to new positions, befitting their age and experience. Such openings for older men, however, were more limited in the case of government laboratories and scientific organisations, such as the National Institute for Medical Research, and similar bodies. In respect to that Institute, Sir Charles pointed out, there were, in fact, only two paths open, the one into the chemical industry, and the other into the universities. Dr. N. P. Inglis, Imperial Chemical Industries Limited, said that the change over of staff, in his organisation, from research to other scientific or technical work, was from 12 to 20 per cent. per annum. Experience in a research department was valuable, in that it gave men a good insight into the work of the organisation, especially as part of the initial training of a research worker should be to allow him to spend a certain amount of time in some of the development departments.

The availability of suitable outlets for the older man had a bearing on the type of appointment that could be offered to him, that is, whether it was intended to be of a temporary nature, or something more permanent. Appointments in large organisations, such as Imperial Chemical Industries Limited and Unilever Limited, were made with the object of providing permanent employment. The National Institute for Medical Research and the National Research Council, Canada, on the other hand, relied upon short-term contracts.

Incentives and Rewards

Means to encourage scientists in their work and consideration of how they should be rewarded for their efforts were the subjects of much interesting discussion. In his paper on incentives, Mr. Stanley Mayne,[8] the general secretary of the Institution of Professional Civil Servants, urged the need for higher incentives in the Civil Service. He drew attention to the high rate of wastage of men in government establishments, and quoted figures to show that in many

* A list of the papers discussed at the conference and referred to in this account of the proceedings will be provided at the end of the concluding article.

cases these men were permanently lost to science.

Speaking, more generally, of research workers engaged in laboratories, he said that, among the other incentives which should be employed, were the provision of educational opportunities for young men, so that they could obtain higher qualifications. They should be made aware of the career value of their work and encouraged by promotion to proceed upwards from grade to grade; they should be made to feel that they were responsible members of a team; and brought into consultation about the objectives, progress and general planning of the work in hand. For the higher-ranking scientists, there should be greater opportunities for discussing their problems with other scientists in the same field of work by attendance at conferences; sabbatical leave with pay; and facilities for the publication of papers by them, with a consequent possibility of rising in the public esteem.

Dr. W. S. Bristowe, head of the central staff department, Imperial Chemical Industries Limited, summarised the incentives, which a scientific career could offer, as money, favourable conditions, good human relations (particularly good leadership in the laboratory), and status. Professor Morris Stein thought that one of the greatest incentives to good scientific research was freedom. Mr. O. W. Humphreys, research laboratories, General Electric Company, Limited, in an earlier discussion, had referred to the fear expressed by university research workers that they would lose their individual freedom when joining an industrial laboratory and he had inquired what could be done to allay this fear. He thought that it was better to provide scientists in industry with freedom rather than to let them waste effort in fighting for it. Dr. A. W. Stableforth, Ministry of Agriculture, Fisheries and Food, felt that if scientists wanted to work on related items outside the immediate research programme, they should be allowed to do so, and be given the support of their superiors. He suggested that about one-third of a scientist's time should be devoted to doing research work of his own choice. In Dr. Stableforth's own organisation, he said, they had what were called "wild ideas" meetings, at which members of the staff were free to express their ideas without being subjected to heavy criticism. He thought that in industrial research to-day there was a tendency to encourage the repression of criticism.

Professor Bernal drew attention to the need for distinguishing between the conditions necessary for good work and true incentives. He pointed out that what Mr. E. McCrensky, Office of Naval Research, Washington, had called "fringe benefits," such as the deferment of National Service, special pensions and insurance, and the option of buying company shares, had now become incentives to a career in science.

Dr. Bronowski, summarising the discussion, said he felt that the only incentive in which there was a wide agreement was status—particularly status among fellow scientists. The discussion had clearly brought out the facts that science was a human and not a mechanical activity; that it offered at all stages an exciting and an exacting career; and that, as Mr. Mayne had shown, the opportunity to enter it was a major incentive to young minds.

Harmful Effect of National Service

During the conference, some rather outspoken comments were made on the effects of National Service, both in respect to the recruitment of scientific staff and in its consequences on the scientists themselves. Mr. F. E. A. Tompson, British Petroleum Company, Limited, said that many young graduates wished to avoid National Service and that, for that reason, many scientists sought employment in the United States. It had been estimated that the services of 10 per cent. of the men holding grants from the Department of Scientific and Industrial Research were lost to this country from that cause. Mr. P. E. Trier, Mullard Research Laboratories, referred to the harmful effects in his organisation resulting from some jobs carrying deferment while others did not. This state of affairs had the effect that certain members of the Laboratories' staff were retained on work carrying deferment when they should be doing other work, which would give them wider experience. He thought that all honours graduates should be exempt from National Service. If this were not possible, there should at least be uniform regulations, covering the granting of all deferments.

In his view, Dr. Bronowski said, the whole system of National Service for scientists was inefficient. There was much evidence that scientists were the last people to send to ordinary National Service. In view of the great shortage of science teachers, he suggested that the best form of National Service for scientists might be for them to spend a certain time, say up to the age of 28, teaching science in schools.

RIG-TESTING HELICOPTERS

DEVELOPING THE "SKEETER"

The growing importance of ground rig-testing closely simulating working conditions in the evolution of helicopters was one of the main themes developed by Mr. T. D. Nisbet, Saunders-Roe Limited, in a lecture on "The Development of the Skeeter Helicopter" given recently in London before the Helicopter Association of Great Britain. The principal problems successfully overcome were ground resonance troubles; the design and proving of a lightweight undercarriage; reducing wear in blade drag-hinge dampers; developing lateral controls acceptable to pilots; eliminating heterodyning torsional vibrations between the tail and main rotors; obtaining satisfactory engine cooling; fatigue-testing the transmission; and developing, in conjunction with D. Napier and Son, Limited, blade-tip H.T.P. rocket boosters for enhancing the take-off (described in ENGINEERING, *September* 14, *page* 350, 1956). *We give below extracts from Mr. Nisbet's written paper describing some of the Saunders-Roe test rigs.*

The problem of fatigue is one which will always hinder the swift development of a helicopter, and it will probably always be essential to confirm the safe life of a component either by running it on a completed aircraft or on a suitable rig, which must impart exactly the same type of loading as would be experienced in operating conditions. The rotor test tower (Fig. 1) has been valuable for diagnosing troubles associated with blades and their suspension systems. Although relatively simple, it can be "flown" since a complete control circuit is incorporated within it. Lift and torque balance mechanisms are fitted, so that the performance of rotor blades can be established.

Fig. 1 The rotor test tower incorporates a complete control circuit. Lift and torque balance mechanisms enable the performance of rotor blades to be established.

The specially developed helicopter instrumentation (described on page 529 of the October 26 issue of ENGINEERING) has enabled the whole of the flight strain-gauging programme on the transmission system to be completed and partially analysed within eight days.

The major obstacle in the development of the Skeeter helicopter has been a particularly violent form of ground resonance. This phenomenon, common to all helicopters with articulated rotor systems, is a divergent oscillation of the helicopter on its undercarriage, depending on a combination of fuselage, transmission, and undercarriage characteristics, in addition to those of the rotor. The main variables to be considered are rotor blade damping, undercarriage leg damping and tyre stiffnesses.

It was decided to attack this problem both theoretically and by practical full-scale test on an aircraft. For the theoretical approach it was essential to provide the mathematicians with accurate data on the natural frequencies and dynamic stiffnesses of the fuselage/undercarriage system, together with the effect of lift on these frequencies.

For this purpose an externally excited spring system was used. The impedance test rig (Fig. 2) is driven by a variable-speed electric motor, which is geared down through V-belts to a large flywheel. From this flywheel there are two connecting rods, one to a balance torsion bar and the other to the main torsion bar, the phase relationship of these bars being 90 deg. The output end of the main torsion bar was connected to the aircraft through a lever and a light push/pull rod. A lift mechanism in the form of a Chinese balance hung from the hangar roof was used to vary the weight on the wheels of the aircraft. By adjusting the lengths of the input and output levers around the main torsion bar, the effect of spring rate could be varied. It will therefore be seen that the frequency of oscillations, the spring output and the lift could be altered to give their effects for the theoretical investigation. A motor-car type brake and drum were fitted around the torsion-bar output so that the aircraft could be damped should the motions become too violent, or alternatively, the aircraft could be violently shaken with a known frequency.

With this rig it was essential that the instrumentation should give ready answers and that all resonance could be accurately picked up. Accurate speed control of the motor was also required; this was obtained within one r.p.m. in approximately 300 r.p.m.

The instrumentation consisted of two methods of recording resonance: by means of photographed Lissajou figures and by measuring frequencies on a Hughes pen recorder, these records being obtained simultaneously. An oscillograph was used to display Lissajou figures, the supplies to this oscillograph being from displacement pick-up units through integrator, attenuator and amplifier systems to the X and Y plates of the oscillograph. It was found by

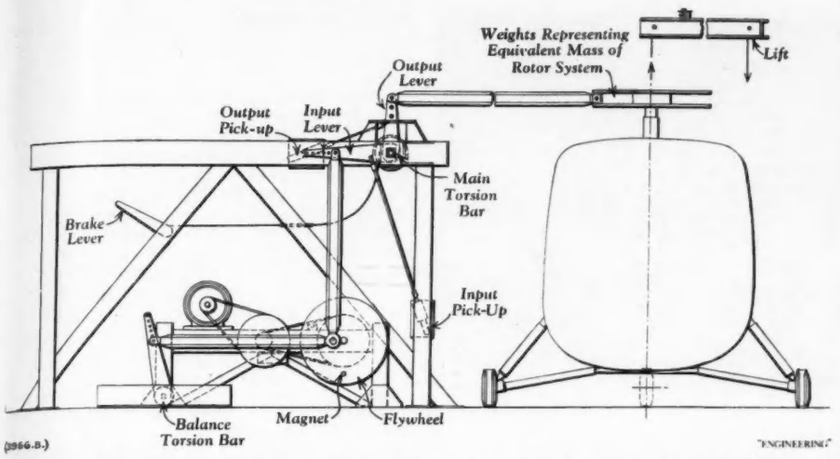


Fig. 2 An impedance test rig was used to determine the natural frequencies and dynamic stiffnesses of the fuselage/undercarriage system.

experiment that Lissajou figures gave an excellent method of detecting these resonances. The input or the output pick-up could be isolated so that calibrated displacements could be measured on the oscillograph tube. It is known that, when a Lissajou figure is displayed the axes of which are at 45 deg., resonance of a natural frequency has been found, and by slowly varying the speed of oscillation the Lissajou figure will topple in a clockwise or anti-clockwise direction. By taking a series of photographs when recording, it was possible to detect resonant frequencies accurately. The Hughes pen recorder received a signal from a small magnet indicator mounted on the driving flywheel, this signal appearing as a "blip" on the recorder trace. Mains frequency was used on a separate pen as a frequency datum and a cross trace was made on a third pen to show the exact instant of oscillograph camera operation.

In parallel with the impedance tests the full-scale ground resonance tests were carried out. In these tests undercarriages with five different damping rates were used in combination with five different damper settings.

The aircraft was restrained at a central point beneath the rotor, and snubber cables were attached to the top of the pylon. The tail of the aircraft was ground picketed by means of a simple spring-loaded snubber. Yaw of the aircraft was controlled by lashing the tail to two further ground pickets on each side of the aircraft and a lashing was used also to restrict the nose movement of the aircraft. If aircraft oscillations became too violent, external restraint in the form of hand-cam-operated cables could be used to snub the aircraft. The snubbing arrangements allowed the helicopter complete freedom of oscillation, with large amplitudes. Only when snubbing was applied in actual cases of ground resonance was this freedom restricted.

The instrumentation for these tests consisted of two potentiometers driving two pens of a Hughes pen recorder, one potentiometer being used to measure the lateral motion of the aircraft and the other to measure the pilot's fore-and-aft control-stick movement.

As a result of these tests, completely safe combinations of drag hinge and undercarriage dampings were evolved. This has been confirmed by a severe flight testing programme.

BLADE DRAG-HINGE DAMPERS

Development work on the blade drag-hinge friction dampers has been concerned with the need for relative freedom from wear and adjustment so that they may be left untouched for reasonably long periods of flying. To facilitate this development, a damper test rig has been designed which uses the same driving motor as the impedance test rig, but incorporates a linkage to vary the amplitude of oscillation of the damper under test.

A strain-gauge bar is used to record the damper load and a simple potentiometer to measure amplitude; mains frequency is used to provide the frequency datum scale. This damper test rig has been used to test various forms of friction damper and can also obtain the characteristics of hydraulic dampers.

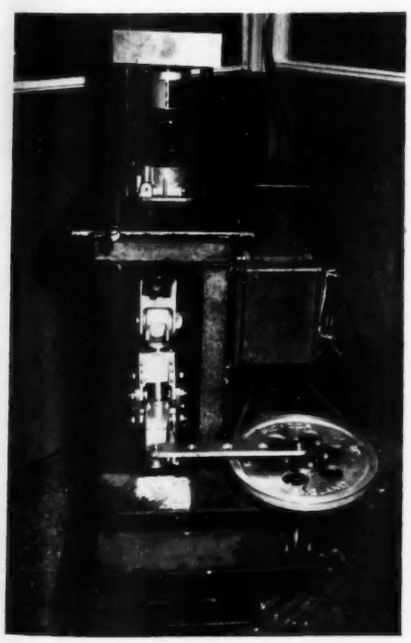


Fig. 3 (left) Blade torsion-bearing test rig.

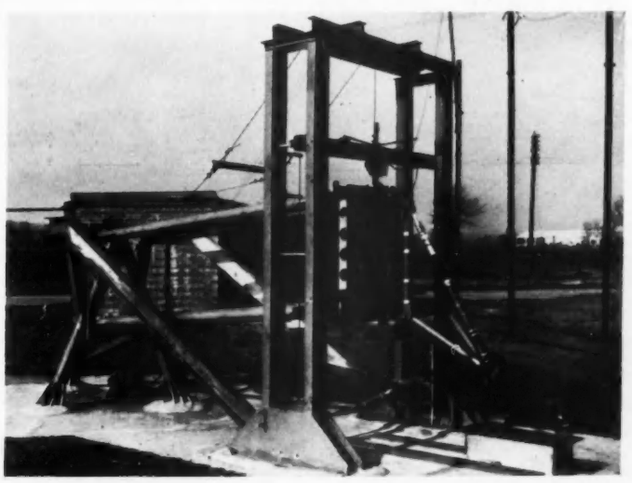


Fig. 4 (right) Undercarriage drop-test rig.

CONTROL DEVELOPMENT

A considerable amount of work has been required in developing an azimuth control which is acceptable to pilots. Much of the undesirable force fed back to the azimuth control stick can be explained by the fact that when the blade torsion bearings are no longer moving, i.e., at each end of the excursion, there is a period of dwell during which time a small amount of oil is squeezed away from the roller faces, so producing higher friction.

A rig has been made to oscillate the bearings under these conditions (Fig. 3). The centrifugal loading of the bearing is simulated by a commercial hydraulic jack and the torsional excitation by a simple crank and electric motor. In parallel with this running test, a number of static tests with bearings mounted back to back have been carried out to measure their frictional torque which may be relatively high. It is only with specially developed and hand-selected bearings that the lightness of control required in small helicopters may be achieved with this form of blade suspension. It was found during these tests that an extreme-pressure lubricating oil was superior to any of the greases at present in use in helicopter controls, both as regards frictional torque and life.

The blade torsion bearings still suffer from limited life, and a torsion-bar blade suspension system is being developed.

STRUCTURAL TESTING

Undercarriage drop tests have been carried out to find the undercarriage reaction loads on a rig (Fig. 4) with a small equivalent mass (200 lb.). It is of the parallel linkage type, using light-alloy tubing and a light-alloy loading platen on which an undercarriage can be attached. The rig can be easily adjusted in height, to allow rapid change of weights, and to provide a simple means of lifting the assembly prior to drop. A standard electrically-actuated bomb release has been used as the dropping trigger.

A Hughes pen recorder gives the history of rig travel, leg closure and the leg loads both at the attachment and within the leg. Mains frequency is used as a time base. The rig travel and leg motion are measured with potentiometers, and loads are measured by strain gauges.

The equivalent "mass" of the rig was found by oscillating it on a calibrated spring. The velocity at impact was checked by timing the free fall to find possible effects of the operating radius of the rig and of friction. From these experiments the "effective air-borne mass" and drop height for various cases were determined.

Contact surfaces can be varied and range from rough concrete to a greased polished steel plate. Photographs show that the surface has little effect on tyre scrubbing.

The components visible in this illustration give some idea of the type of work which is normally passing through the machine shop at the Daventry works of British Timken, Ltd.

HEAVY-DUTY TAPERED-ROLLER BEARINGS

LARGE COMPONENTS TO PRECISE LIMITS

It was from the steel industry that the demand for large, heavy-duty roller bearings first arose, and this industry continues to be a major user of such bearings, though numerous other applications now exist for them. Among these may be mentioned large machine tools, testing equipment and armaments. British Timken, Limited, Duston, Northampton, have long been manufacturers of tapered-roller bearings of this type, and in 1954 decided to build a new factory which would cater for the large and growing demand at home and abroad. A site was chosen at Daventry, Northamptonshire, a few miles from the Company's head office and principal factory at Duston, and the Daventry works are now in full operation.

The works, which are specially designed and equipped for heavy bearing production, are of single-storey construction, the ground plan taking the form of a letter E. Provision has been made for easy expansion. Daventry works cater for the bearing needs of the three wide strip mills in Great Britain, and for similar mills in nine overseas countries. Bearings are made for many other rolling-mill, machine-tool and engineering applications, and export business is conducted with more than 15 countries. The plant installed is capable of dealing with the complete machining, heat treatment, grinding, assembly, inspection and testing of a range of bearings from 20 in. outside diameter upwards, the largest which could be handled at present being in the region of 10 ft. The bearings are made from case-hardening high nickel steel, and are almost invariably of the multi-row type, 2 and 4 row being the commonest, while 6 and 8 row bearings are also produced.

Heavy-duty bearings are basically the same as any others in the large range of tapered-roller bearings made by British Timken, Limited, but neither the quantity nor the size is suitable for the quantity - production methods which are used on the smaller bearings. The largest bearing at present being made at Daventry weighs 4½ tons in the assembled condition, and it is obvious that many of the components will require machining and grinding singly, it being necessary of course, to work to precise limits in all cases. There are, however, certain components such as tapered rollers and cage pins which can be made by quantity-production methods. The machine shop is therefore equipped with machine tools ranging from vertical boring mills for roughing and finishing cups and cones, to capstan and automatic lathes used for the production of rollers and cage pins. Cups, cones, and spacers are machined from forged rings, while the rollers are turned from stampings or parted-off from bar material, according to size. Some rollers are also produced by cold heading in a machine similar to that used for bolt making. The actual machining of components calls for no special comment.

HEAT TREATMENT

Hardening and tempering of roller-bearing components not only calls for special care and precise metallurgical control, but also presents problems which necessitate the use of special-purpose equipment. All components pass through the sequence of carburising, refining, normalising, hardening, de-greasing, tempering and shot blasting, and both pack-type and gas-carburising furnaces are in use. The gas-carburising section of the heat-treatment shop, which is equipped with Birlec pit-type furnaces is laid out for easy maintenance. The furnaces are erected on the floor, with an elevated loading and unloading platform, served, as is the remainder of the shop, by overhead cranes. Components are lifted to the platform, stacked with the smaller inside the larger to utilise space to the best advantage, and charged to the furnaces by crane. Access to all parts of the furnaces is possible from beneath the platform.

Carburised components are refined by cooling in air and then normalised by re-heating for long pre-determined periods at a low temperature and cooling in air once more. Hardening of cups and cones calls for the use of special fixtures to prevent distortion during quenching. Components are heated slowly and soaked in the normal way, and then withdrawn from the furnace on to the perforated base of a hardening fixture or plug. The upper part of the plug is lowered into the component at once and clamped to the base; the whole assembly is then quenched in oil. De-greasing follows, and the components, after inspection, are tempered in air-circulation furnaces and then shot-blasted ready for grinding. Other equipment in the hardening shop includes roller hearth furnaces used for the tapered rollers, and furnaces for heat-treating the tools and gauges used throughout the works. All the process work in the shop is controlled by a production laboratory attached to it.

GRINDING AND ASSEMBLY

Cups and cones are first surface ground on a large Blanchard machine with a magnetic chuck.

Carburising is carried out in both pack type and gas furnaces, the latter being of the pit type, erected above floor level for easy maintenance.

Grinding to fine limits is necessary on large components, and the equipment and operating sequences are specially chosen to prevent distortion.

Cups are then ground on the outside diameter and bore, while cones are ground on the bore, race, and rib. Radius grinding is also necessary. The grinding sequence is planned in all cases to eliminate distortion, and in the case of spacers co-operation is necessary with the assembly shop to ensure that the finished bearing will have the necessary end play. Extensive use is made of magnetic chucks on the grinding machines, and there is a de-magnetiser in addition to any de-magnetising equipment which is provided on the machines. Rollers are ground on centreless grinding machines, hopper feed being used where possible.

Components from the grinding shop pass direct to assembly, where they are assembled, tested, and run in. Finally the roller retaining pins are welded in position, one being left cottered so that a roller can be removed for race inspection while the bearing is in service.

Systematic inspection from raw material to finished product enables a close check to be kept on quality and dimensional accuracy, patrol inspectors being employed where appropriate, and full inspection being the rule before a component passes from one process to another. Some idea of the dimensional accuracy maintained is given by the fact that even the largest of the bearings do not vary more than 1/2,500th of the diameter.

AUTOMATIC CONTROL OF STRIP MILL

MAGNETIC AMPLIFIERS EMPLOYED

To meet the ever-increasing demand for steel of all types, rolling mills have become increasingly faster and more powerful. Such developments are largely dependent on the progress of control scheme design. Typical of present-day trends is the five-stand tandem cold reduction mill which recently commenced operation at the Velindre tinplate works, near Swansea, of the Steel Company of Wales. This new mill will eventually double the company's production of cold-rolled tinplate and help to reduce the United Kingdom's imports of this material.

The mill will roll steel strip to tinplate gauges at speeds up to 5,000 ft. per minute. The stand work rolls have a diameter of 21 in. and a length of 42 in., with back-up rolls of 53 in. in diameter. The tension reel has a diameter of 20 in., building up to a maximum of 72 in. with a finished coil, which may weigh up to 36,000 lb. and consist of 6 miles of material. The mill manufacturers were Davy and United Engineering Company, Limited, Park Iron Works, Sheffield, 4, and the main drive and control equipment were supplied by the British Thomson-Houston Company, Limited, Rugby. The consulting engineers for the electrical equipment were McLellan and Partners, 32 Victoria-street, London, S.W.1.

The machine arrangements and control scheme are basically similar to the installation at the Steel Company of Wales' Trostre tinplate works which was completed in 1951. However, magnetic amplifiers are used extensively in the control circuits at Velindre in place of rotating amplifiers. Magnetic amplifiers give far faster response, helping to maintain the accuracy of the gauge and to reduce strip wastage. Another advantage of magnetic amplifiers is that their components, namely transformers, chokes, rectifiers and resistances, are all completely static, simple and robust. A further improvement in the new mill is the use of high-speed circuit-breakers which are capable of contactor duty and therefore render separate line contactors unnecessary.

The stand and reel motors are compound-wound machines with off-set pole-face compensating windings to give added stability. To reduce intertia, multi-armature motors are used for stands 2 to 5 and for the reel, each armature having a greater ratio of core length to core diameter than is usual for a direct-current machine. The stand motors have low-inertia drum construction armature spiders, while the reel motor, which has a relatively small armature diameter, has the four armature keys welded directly on to the shaft.

The speeds and powers of the stand and reel motors are given in the following table:—

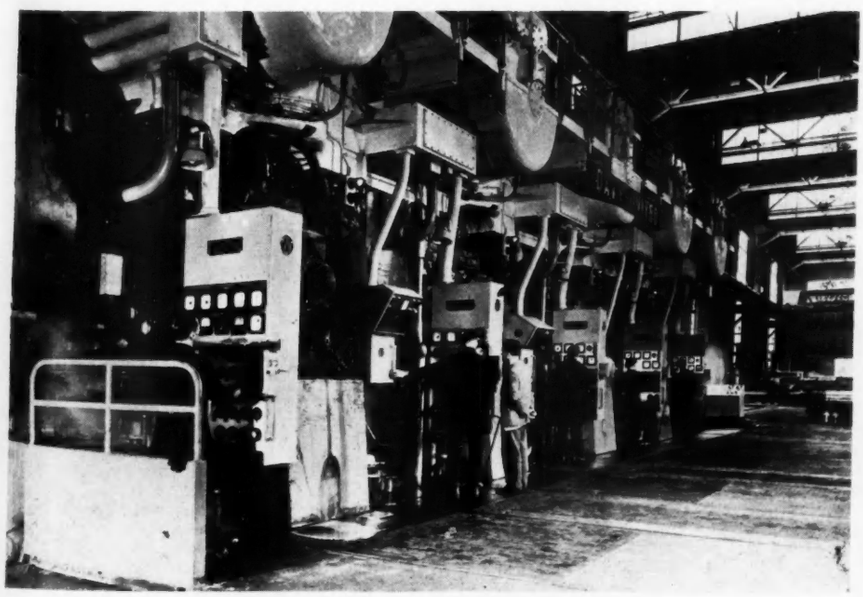
	No of Armatures	Total h.p.	Output, r.p.m.	Mill, f.p.m.
Stand 1 ..	1	1,750	90/255	345/1400
Stand 2 ..	2	3,500	125/304	480/1670
Stand 3 ..	2	3,500	200/445	770/2440
Stand 4 ..	2	4,000	350/645	1340/3550
Stand 5 ..	3	5,500	500/910	1920/5000
Reel	2	900	233/955	

Each stand motor armature is supplied by a 1,600 kW 600 volt generator, and the double, armature reel motor is supplied by one 731 kW 650 volt generator. The generators are grouped in two sets each driven by a 9,000 h.p. 11,000 volts synchronous motor. The latter can be started either reactively or direct-on-line.

The main machines are cooled by a re-circulating air system, a common plenum being maintained in the motor room basement. The cooling air enters the machines at the drive end and leaves at the commutator end. The commutators are open to the motor room, thereby preventing commutator dust from fouling the re-circulating air. The small amount of air lost through the commutator seals is replaced by a separate make-up fan and filter supplying clean air to the plenum.

Mill speed is regulated by armature voltage control, and relative stand speeds are adjusted by armature voltage and field control. The speed of the whole mill is raised by increasing the voltage of all the generators in unison. Each main field consists of two windings, one supplied from the individual generator field magnestat and the other from the exciter common to all the generators. The mill reference voltage is controlled from the same rheostat and all stand reference voltages vary with the mill reference. Compensation for variation of speed with load is based on the armature load current. The variable speeds required for rolling duties are pre-set on small setting rheostats which provide reference voltages which affect the position of the master rheostat. Control of the mill from the mill cabinets is effected by "Thread," "High-Thread," "Run," "Hold" and "Stop" push buttons. In addition mill speed can be controlled by "Raise," and "Lower" push buttons which accelerate or retard the mill at a reduced rate.

A constant tension must be maintained in the strip between stand 5 and the reel in order to build up the finished coil evenly and to keep the gauge uniform. With constant strip speed the reel motor must slow down as the coil diameter increases, the necessary range of speed being obtained by magnetic amplifier control of the motor field.



In the Velindre strip mill each stand has its own automatic speed control. In addition, an overall control can vary the speed of the mill as a whole.

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NEW PLASTICS FIRE HOSE

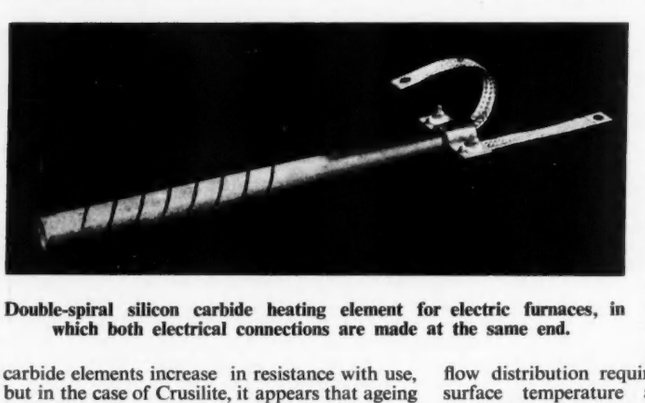
A new plastics and synthetic fibre fire hose has been developed by the British Tyre and Rubber Company, Limited. It consists of plastics cover and linings of polyvinyl-chloride fused on to a synthetic reinforced fabric. The chief advantages claimed are its fire-resistant qualities and its resistance to contamination by oil, acids or alkalis. It can also, it is claimed, be exposed for years to salt or chemical-laden atmospheres without fear of deterioration. This Plastidry hose, as it is called, is claimed to have an output of as much as 60 per cent. more water than a canvas hose and 10 per cent. more than a rubber-lined hose owing to the reduced friction.

The manufacture of fire hoses is a difficult compromise between technical and economic factors on the one hand and the prejudices of certain markets (notably the United States) to which there is a useful export trade on the other. Such fire hoses must bend easily, have self-caulking properties, resist abrasion, have the necessary bursting strength and must not easily rot. Some of these requirements are incompatible and the desirability of reducing the number of variables in the technical problem led to the development of a thick rubber lining which makes the hose exceedingly heavy but which is very often the official specification in the United States. One of the most useful developments in recent years has been the thin rubber-lined hose consisting of a cambric base with layers of latex on it and the developments in rubber-linings have been accompanied by an increased use of synthetics, such as nylon, which are cheaper per lb. of tensile strength than the flax or hemp which is usually used. The new plastics and synthetic hose will have the big advantage of having had the prejudice broken down by those who have pioneered a thin rubber lining.

SILICON CARBIDE HEATING ELEMENTS FOR ELECTRIC FURNACES

Among the latest additions to the range of products of the Morgan Crucible Company Limited, Battersea Church-road, London, S.W.11, are the Crusilite electric-furnace heating elements, which, they inform us, are capable of being operated at temperatures of up to 1,575 deg. C. (2,867 deg. F.). The elements consist of one-piece silicon-carbide units, the central hot zone of which is in the form of a spiral of the requisite length. Five diameters are available, namely, 10, 14, 18, 22 and 28 mm., with a range of hot-zone and overall lengths to suit all the commonly-used designs of furnaces.

The makers state that the method of manufacture permits the maintenance of a resistance tolerance of $\pm$ 10 per cent. of the nominal, and that, where manufacturers supply elements as a set for a particular furnace, the resistance will not vary by more than $\pm$ 5 per cent. of the mean. It is pointed out that tolerances of this order mean that it is possible to improve temperature distribution within a furnace—particularly where the elements are connected in series. All silicon carbide elements increase in resistance with use, but in the case of Crusilite, it appears that ageing is so slow that a voltage reserve of only 40 per cent. is normally sufficient to maintain operating efficiency throughout the life of the elements.



Double-spiral silicon carbide heating element for electric furnaces, in which both electrical connections are made at the same end.

A new form of the heating element which will be placed on the market shortly is that shown in the illustration and known as type DS. In this the hot zone consists of a double spiral element which enables both electrical connections to be made at the same end instead of one at each end as in the case of the ordinary unit, thus widening the field of application of the element.

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SAROY TOUGHENED POLYSTYRENE SHEET

A rigid non-toxic plastic sheet material known as Saroy, which possesses high impact strength and elongation properties, good dimensional stability, low water absorption and good durability, has been placed recently on the market by Saro Laminated Wood Products, Limited, Folly Works, Whippingham, East Cowes, Isle of Wight, a daughter company of Saunders-Roe Limited, Osborne, East Cowes. We understand that the material is made from Styron 475, a modified polystyrene, and it is available in a number of standard colours.

A 16 mm. sound film, in colour, made by the Saro Film Unit, has now been released. It shows the manufacture of the sheet at the Cowes Works of the company, the method of test adopted to control quality, the various processes employed for forming the sheet into articles, and typical applications. These include liners for refrigerators, baffles, advertising signs and displays, trays and dishes for the display of food, and toys.

The principles of the various vacuum-forming processes shown in the film consist essentially of heating the plastic sheet until the material is flexible; then using the sheet as a diaphragm, the air is evacuated between the sheet and the mould. Atmospheric pressure shapes the sheet on to the contours of the mould, and, within seconds, the formed material is rigid and can be removed from the mould.

Copies of the film are available, on loan, by arrangement with Saro Laminated Wood Products, Limited, at the address given above.

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EFFUSION COOLED TURBINE NOZZLES

Use of Permeable Blade Surface

With the desire to increase turbine operating temperatures the problem of blade cooling has assumed considerable importance. Some experiments to this effect have recently been carried out by Mr. S. J. Andrews, Mr. H. Ogden and Miss Jane Marshall of the Department of Scientific and Industrial Research. Their results have been published in the D.S.I.R. current paper No. 267, of which the following is a summary.

The investigation, which also included a theoretical study, was concerned with effusion cooling of a turbine nozzle blade in a cascade tunnel. The permeable surface of the test blade was made of woven stainless-steel wire cloth brazed to the spine in such a way that the effusion flow could be separately controlled over a number of regions on both convex and concave surfaces of the blade form. In this way, the chordwise effusion flow distribution required to produce uniform surface temperature at mid-span, and the temperature distribution at mid-span produced by uniform effusion could be determined and compared with corresponding theoretical predictions.

In the laminar-flow region of the blade boundary layer, the effusion flow to achieve a required temperature was much higher than predicted, and in the turbulent flow region the flow was lower than predicted. The two requirements combined to give an overall cooling effectiveness for the blade surface which was very little different from an internally cooled impermeable rotor blade also tested in a cascade. The large effusion flow required in the laminar region might have been due to the practical limitation of the number of separately controllable effusion regions, since the static pressure gradient over the leading-edge part of the blade surface was very large and the variation in effusion cooling air supply pressures required had also, therefore, to be very large. The solution to this problem lies in the use of permeable materials of either variable permeability or variable thickness over relatively wide ranges.

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ALUMINA FROM FRENCH GUINEA

Aluminium Limited have announced that they are establishing a new alumina plant in French West Africa over the next five years. The investment will be through a wholly owned French subsidiary at a cost of about 100 million dols. and will serve export markets. Capacity is expected to be about 250,000 tons of alumina per annum. The whole project involves the building of a communication system and a town as well as the actual industrial installations. The initial investment of 100 million dols. will be used mainly for providing the basic transport and housing requirements of what, in effect, will be a new industry established in completely undeveloped territory.

The new scheme is based on the surveying of new bauxite deposits and it is quite separate from the project announced earlier this year by Aluminium Limited to establish an aluminium industry in French West Africa. The production of aluminium being dependent on cheap electric power involves a study of the hydro-electric potential of the Konkoure River. Should reports on this study be favourable, French Guinea would then move forward, presumably, to establish a similar joint hydro-electric and aluminium scheme such as is in progress on the Volta River in the Gold Coast. The process of gradually building up an aluminium industry in French territory has been going on for some years. In 1952 a plant to produce beneficiated bauxite was completed at a cost of about 12 million dols. and the ore has been shipped over the past two years to North America and Western Europe at a rate of 500,000 tons a year.

With the growing prospect of a large long-term demand for aluminium alloys, the future of these plans in West Africa is assured, provided the costing has been accurate, the hydro-electric power is cheap enough (in the case of producing aluminium from alumina), and the supply of engineers is sufficient to supervise the installations and make reasonably efficient operatives out of the local labour supply. The only technical development which could seriously upset these calculations would be further progress in the use of clay instead of bauxite for aluminium, a process which was developed in Germany during the war and which has made further progress in the United States.

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FULL-SCALE TESTS FOR COKE QUALITY

In his opening speech at the seventh conference of the British Coke Research Association, held in London on November 7, Mr. Leslie O'Connor, C.B.E., chairman of the Association, announced that orders had been placed for the erection of a new Coke Research Centre for the Association, adjacent to the National Coal Board's Avenue coking plant, Chesterfield, opened on October 30 and described on page 546, November 2.

In addition to laboratories, workshops and offices, the Centre will be equipped with one full-size silica coke oven, complete with a regenerative heating system and a by-product plant. Comprehensive blending equipment for the oven, including facilities for the addition of various constituents to the coal and special pre-treatment methods for the oven charge are to be provided.

It has, of course, long been known that the high-quality coking coals, so long an asset to the iron works of this country, are becoming exhausted and for many years much thought and ingenuity has been given to the blending of coking slacks to produce a satisfactory metallurgical coke. Perhaps the most important quality required in coke intended for blast-furnace consumption is consistency. While it is difficult to measure consistency and to express it by some numerical value, it is generally acknowledged that among the most important factors making for consistent coke are the blending of the raw fuels and the temperature attained in, and the duration of, the carbonising operation.

These three factors may be closely controlled and will no doubt be the subject of extensive research using the new equipment. An adjacent general workshop laboratory for intermediate-scale testing plant, plant-development work and the study of new methods of carbonisation is also being built.

Construction work on the site has commenced and the buildings should be completed in approximately 18 months.

Book Reviews

NON-LINEAR DIFFERENTIAL EQUATIONS

Ordinary Non-Linear Differential Equations in Engineering and Physical Sciences. By N. W. McLACHLAN. Second edition. *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.4.* (35*s.*)

Even an apparently slight extension of the generality of a physical problem often immeasurably increases the difficulties encountered in its solution and sometimes renders it quite intractable with the mathematical techniques at present available. Thus whereas the motion of two bodies (sun and a single planet), attracting one another in space according to the Newtonian law of gravitation, can be worked out comparatively simply, no usable mathematical method has yet been discovered for completely describing the motion in space of three mutually attracting bodies (sun and two planets). A somewhat similar situation arises in the transition from linear to non-linear problems. The former lead to linear differential equations which have been very thoroughly studied and for which explicit analytical solutions have been found; the latter lead to non-linear differential equations and almost nothing of a general character is known about them. The principle of superposition, for instance, which figures so prominently in the handling of linear differential equations, is inapplicable to the non-linear type. Linearly independent solutions of a non-linear differential equation do not exist, and the general solution is a function of the constants of integration which, in a physical problem, are determinable from the relevant initial or boundary conditions.

A few non-linear differential equations are integrable exactly using suitable transformations or (apart from some exceptions) in terms of Jacobian elliptic functions. Certain of these, including the Bernoulli equation, a particular form of Riccati's equation, the Lane-Emden equation, the equation of motion of the simple pendulum and the elastica, are dealt with first. However, in the absence of general methods capable of yielding exact solutions of non-linear differential equations, recourse must be had to methods of approximation, and attention confined to particular equations representative of significant applications in engineering and physics. In the most important class of these the dependent variable is, in its final steady state, a periodic function of time. When the departure from linearity is small, the resulting steady-state motion usually constitutes only a minor modification of that derived by ignoring the non-linear terms in the equation, but, when the terms contributing to non-linearity assume a greater relative importance, the ensuing motion may bear little or no resemblance to the equivalent non-linear motion. For instance, in the first approximation, non-linear control terms affect the frequency but not the amplitude, and non-linear damping terms affect the amplitude but not the frequency, whereas, in higher approximations either type of term influences both frequency and amplitude. Moreover unless it is evident or can be proved that the solutions are not divergent, the outcome of the analysis may well be meaningless.

The standard procedures for obtaining approximate periodic solutions of non-linear differential equations by successive approximations derived by solving a set of linear differential equations subject to the imposed initial conditions; by the perturbation method borrowed from celestial mechanics; and by assuming a Fourier series and determining early coefficients therein, are fully described. Illustrations are provided by the self oscillations of a thermionic valve circuit and of an electric motor-generator combination, while other topics of interest covered are sub-harmonics and intermodulation frequencies in moving-coil loud speakers. The use of the method of slowly varying amplitude and phase is next described and illustrated by an investigation of surges in hydro-electric installations. Examples are also given of the method of equivalent linearisation, developed by Kryloff and Bogoliuboff, which consists in defining an equivalent system, the parameters of which are adjusted so as to secure equality of work per cycle for the non-linear and the equivalent linear system. The discussion of equations with periodic coefficients is based on the theory of Mathieu functions and introduces self-excited oscillations due to solid friction and aerodynamical forces, as exemplified by the spectacular disaster of the Tacoma suspension bridge.

In certain problems, particularly those in which any attempt at linearising the differential equation completely changes its essential character, the only direct line of attack is by recourse to graphical and numerical methods. Two of these, the graphical construction of isoclines and the numerical solution by finite differences, are described and applied to typical problems, among them relaxation oscillations and the heavy elastica. Increasing use is likely to be made, in the future, of computing machines in solving more complex types of non-linear differential equations. Another matter of central importance in non-linear problems is the question of stability, since it affords guidance as to the type of solution to be anticipated. An important chapter defines the various singularities of differential equations of the first order, discusses stability criteria and presents four theorems on the types of solution of certain non-linear differential equations. This and the final brief chapter on fluid flow in two dimensions in which the Maclaurin series is employed are new. Two appendices, dealing with sound waves of finite amplitude in a loudspeaker horn and Mathieu's equation as a stability criterion, are followed by a set of 52 problems, to which answers are provided.

The desire to achieve a clearer insight into less idealised versions of real physical problems makes a study of non-linear differential equations indispensable. Dr. McLachlan, in this volume, provides a sound and attractive exposition of our present knowledge concerning the more important types of ordinary non-linear differential equations. It is to be hoped that he may be persuaded to follow it by a further volume on non-linear partial differential equations.

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POWER IN THE SHOPS

Factory Electrification. By F. T. BARTHO and C. H. PIKE. *Macdonald and Company* (*Publishers*), *Limited*, 16 *Maddox-street, London, W.*1. (35*s.*)

"Experience," write the authors, "shows that in practice the problems that arise in factory electrification are concerned with the correct selection, operation and maintenance of the electrical distribution equipment and the motors." These problems can only be resolved by understanding the principles involved and by knowing the range of equipment available to meet particular requirements. It is therefore the main purpose of this book to discuss factory electrification in terms of principles and the capabilities and limitations of the various forms of equipment.

With this end in view Messrs. Bartho and Pike lay down the general requirements for electrical installations in factories and then go on to describe main distribution switchgear, power transformers, cables and wiring systems, alternating and direct-current motors and their control gear and applications. Stress is laid on constructional details and the treatment is practical, a useful feature being statements of what ought not to be, as well as what should be, done. There is, of course, no deep descent into theory, but the text is enlivened by numerous half-tone and line illustrations.

The scope of the book is, however, narrower than its title would suggest. Artificial lighting, which is an important feature of a modern factory installation, is dismissed in a couple of paragraphs and the same number of illustrations, which is surely considerably less than its due. Ventilation and heating receive no mention at all. Neither is anything said about intercommunication and signalling systems. The most surprising omission, however, is the absence of any information regarding the static rectifier, which, as the recent Machine Tool Exhibition has shown, is playing an increasing role in factory electrification. In one or other of its forms it is a most useful piece of equipment, but its operation and maintenance require expert attention which should certainly bring it into the purview of the factory engineer. When a revision is called these points might receive consideration.

It would be wrong, however, to give the impression that this book is not adequate within the chosen limits. It will provide many factory engineers with the information they require in easily assimilable form, and is therefore to be recommended to their attention.

* * *

NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

Hardness and Hardness Testing from 1937 to 1955: A Bibliography. *Industrial Diamond Information Bureau, St. Andrew's House*, 32-34 *Holborn Viaduct, London, E.C.*1. (5*s.* 6*d.*)

With the inclusion of practically all the material available up till the end of 1955, the aim of the compilers of this bibliography has been to furnish the investigator in the field of hardness, and in particular microhardness, with the means of obtaining up to date information on any branch or aspect of hardness, and of comparing his own work with that of others. The bibliography contains not only work specially devoted to hardness testing, but also work in which hardness testing was used as one of the methods of investigation.

Progress in Nuclear Energy. Series III. Process Chemistry, Vol. 1. Edited by F. R. BRUCE, J. M. FLETCHER, H. H. HYMAN and J. J. KATZ. *Pergamon Press, Limited*, 4 *and* 5 *Fitzroy-square, London, W.*1. (84*s.*)

This volume consists of selected papers on chemical processing methods employed by the world's leading countries in their programmes of atomic energy for peaceful uses. It covers the whole field of chemical processing, including the recovery and purification of uranium and thorium from their ores, reactor-fuel processing, and methods of producing radioisotopes. The text is based on the proceedings of the 1955 Geneva Conference on the Peaceful Uses of Atomic Energy, but, in addition, much previously unpublished information is included.

The Theory of Machines: A Text-book for Engineering Students. By THOMAS BEVAN. Third edition. *Longmans, Green and Company, Limited*, 6 *and* 7 *Clifford-street, London, W.*1. (26*s.*)

This text-book is intended mainly for engineering students preparing for university degrees or institution membership examinations, and is based on lectures given at the Manchester College of Technology. Particular attention is given to graphical methods of solution. In the third edition the sections on gyroscopic motion, velocity and acceleration diagrams, toothed gearing, epicyclic trains, inertia forces in mechanisms, and vibrations, have been revised and amplified, and some of the diagrams have been redrawn. Problems are provided at the end of each chapter, and answers are given at the end of the book.

Jig and Fixture Design. By P. S. HOUGHTON. *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (36*s.*)

This text-book, intended for production engineering students at technical colleges, is based on notes compiled by the author when lecturing at the Central

Technical College and Aston Technical College, Birmingham. It covers production planning, materials, general design considerations, standard clamping methods, indexing, drill jigs, tapping, boring, milling, broaching and grinding fixtures, gears, power clamping, air-operated equipment, dimensional data and standards, and motion study. A series of problems for students is provided at the end of the book.

Textile Machinery Index. Compiled in co-operation with the Textile Machinery and Accessory Manufacturers' Association. Published by *John Worrall, Limited, Central Works, Oldham, Lancashire.* (42*s.*)

This, the first edition of a new work, has been compiled in association with the Textile Machinery and Accessory Manufacturers' Association. It is divided into a number of sections devoted to textile machinery, accessories, mill supplies and services, textile chemicals and specialised equipment, and supplies for textile-machinery makers and engineers. To facilitate reference to the various sections, a centre index is provided; further aids include "thumb-cuts" and the adoption of contrasting colours for the paper.

Selected Combustion Problems. II: Transport Phenomena; Ignition; Altitude Behaviour and Scaling of Aero Engines. AGARD Combustion Colloquium, Belgium, December 5 to 9, 1955. *Butterworths Scientific Publications*, 88 *Kingsway, London, W.C.*2. (90*s.*)

This report of the second Combustion Colloquium organised by the Advisory Group for Aeronautical Research and Development of NATO includes significant technical comments in the discussions and the authors' replies. Some of the papers are in English and some are in French. The subjects covered include aircraft engine performance, fuels for turbojets, fundamentals of flammability and ignition, the ignition of flowing gases, ignition in liquid-fuel rocket motors, thermal ignition, fundamentals of aerothermochemistry (the flow phenomena of compressible fluids in which chemical reactions take place), convection at high speeds and high temperature, correlations of thermodynamic and transport data, high altitude combustion in turbojets, and similarity, scaling and fundamental parameters in combustion in gas turbines and rocket motors.

Resistance Welding: Theory and Use. Prepared by the Resistance Welding Committee of the American Welding Society. *Reinhold Publishing Corporation*, 430 *Park-avenue, New York* 22, *N.Y., U.S.A.* (4.50 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (36*s.*)

All the various resistance-welding processes are covered by the compilers of this book, and the different types of resistance welding machines, electrodes and controls now in use are also described. Moreover, the weldability of different metals and the manner in which quality control and inspection tests and methods are applied to obtain consistently good welds, are discussed. Glossaries of terms and lists of welding symbols and of specifications have been included, and the aim has been to employ clear and simple language throughout the work.

Chromium. Vol. I: Chemistry of Chromium and its Compounds. By MARVIN J. UDY. *Reinhold Publishing Corporation*, 430 *Park-avenue, New York* 22, *N.Y., U.S.A.* (11 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (88*s.*)

The first five chapters of this new work are of a general nature, dealing with the history, mineralogy and geology, and the analytical chemistry of chromium, the relation of chromium to health, and the occurrence of the metal in soils, plants and animals. The remaining ten chapters are concerned with the physical and chemical properties of chromium compounds used in the textile, tanning, wood preservation, oil and gas, and other industries and for corrosion prevention and producing pigments. The companion, *Chromium, Vol. II*, is to deal with the metallurgy of chromium and its alloys.

The following reports may be obtained from the Librarian, College of Aeronautics, Cranfield, Bletchley, Buckinghamshire:—

The Effect of Vibrations on the Mechanical Properties of H.R. Crown Max and Nimonic C.75. By J. JAGACIAK and J. W. JONES. Report No. 91. Test castings were designed to produce data which would help in the production of gas-turbine blades as castings. For castings in H.R. Crown Max the investigation was limited to the effect of sub-sonic frequencies and range of amplitudes; but in the experiments conducted on Nimonic C.75, both sub-sonic and sonic ranges were investigated. It can be concluded that certain frequencies notably improve the quality and properties of castings. This effect is attributed to the formation of more uniform and smaller crystals during this process, and to an increase in density.

Investigations into a Photoelastic Method for Direct Measurement of Surface Strains in Metal Components. By J. R. LINGE. Report No. 97. (5*s.*) Surface strains were investigated in a metal component with optically sensitive material bonded to the component. The photoelastic materials employed were Catalin 800, C.R.39, and the Marco resins S.B.26C and S.B.28C, in conjunction with light alloy, magnesium and mild steel. The major part of the investigations is concerned with producing good adhesion between the photoelastic material and the metal surface, coupled with satisfactory light reflection from the latter. Results of the measurement of both elastic and plastic stress concentrations at holes in plates subjected to uniform tension are presented, together with a qualitative analysis of the effect on stress distribution of the variation of the pin-to-hole clearance in lugs. It is concluded that the technique may be adaptable to the examination of dynamic stresses under repeated loading when more sensitive photoelastic materials become available.

Equipment Used for Boundary Layer Measurements in Flight. By F. M. BURROWS. Note No. 49. (5*s.*) A description is given of the design and construction of a large multi-tube manometer and two fixed-head type boundary-layer combs to be used for measuring the boundary layer characteristics of a swept-back wing in flight.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Wheel Lathe. CRAVEN BROTHERS (MANCHESTER), LIMITED, Reddish, Stockport. Lathes for turning the treads and flanges of wheels mounted on their axles, to suit railway locomotive, tender, carriage and wagon, or tramway wheels. Range of sizes to suit wheel diameters from 3 ft. 3 in. to 7 ft. Optional extra equipment is available for such operations as axle journal re-turning and burnishing, tyre boring. Fully automatic, electrically operated; profile copy-turning equipment is also available. Illustrated brochure.

Engineer's Tools. FIRTH BROWN TOOLS, LTD., Speedicut Works, Carlisle Street East (P.O. Box No. 59), Sheffield, 4. London warehouse and tool delivery service newly established at 2, Warwick-place North, Warwick-way, Victoria, S.W.1. Stocks carried of all standard sizes of twist drills, slitting saws, reamers, tool-holder bits, butt-welded lathe and planer tools, milled-tooth files, engineer's and saw files and hacksaw blades. Illustrated brochure.

Earth Continuity and Bonding System. PORTER ELECTRICAL PRODUCTS, LTD., 2 North Park-road, Harrogate. Description of the Portaway earth-continuity and bonding system, which has been designed to replace plain copper strip. It includes clamps and other accessories and is made in four sizes for currents from 5 to 100 amperes; 100 to 200 amperes; 200 to 300 amperes and 300 to 500 amperes. Technical and installation details. Illustrated pamphlet.

Aluminium Casting Alloy. ALAR LTD., 3 Albemarle-street, London, W.1. Revision of the firm's individual data sheet concerning the properties and uses of Alar-21, an aluminium-silicon-copper-zinc alloy now re-named LM-21 since this material has been incorporated in B.S. 1490. This specification covers aluminium-alloy ingots and castings for engineering purposes.

Hard-Chromium Deposits. THE CLIMAX ROCK DRILL AND ENGINEERING WORKS, LTD., Carn Brea, Redruth, Cornwall. Description and typical applications of the "Climax-Durion Hard-crome" deposition process for providing surfaces of great hardness and very high wear-resisting properties on steels and other metals, with the exception of aluminium. Illustrated leaflet.

Electronic Components. THE PLESSEY CO. LTD., Chemical and Metallurgical Division, Wood Burcote-way, Towcester, Northamptonshire. "Plessey at Towcester" describes dust cores, ceramic capacitors, ceramic insulators, magnetic ceramics, electrolytic capacitors and other products of the factory; properties and technical details are given. Illustrated brochure.

Electric Hand Grinders. THE ACRU ELECTRIC TOOL MFG. CO. LTD., Chapel-street, Stockton-road, Levenshulme, Manchester, 19. Martin electric hand grinders, for small polishing and die sinking work. Five types, including one with low speed for drilling; grinding speeds 16,000-18,000 r.p.m., taking grinding wheels up to 25 mm. in diameter. Leaflet.

Continually-Cast Bronzes. ENFIELD ROLLING MILLS LTD., Brimsdown, Enfield, Middlesex. Brief description of the Encon continuous-casting equipment recently installed at Brimsdown for the production of bronze and other copper-base alloy rods, tubes and sections. Tables and illustrations indicate the improvements in properties obtained by continuous casting. Illustrated booklet.

Electric Radiant Heating Panels. DULRAE, LTD., Bridge-road East, Welwyn Garden City, Hertfordshire. "Medrae" electric radiant heating panels, with or without thermostatic control. Sizes of standard units from 12 in. square to 48 in. by 24 in.; loading 110 watts per sq. ft., giving surface temperature of approximately 150 deg. F. Leaflets.

Road Hire Services. BRITISH TRANSPORT COMMISSION, 222 Marylebone-road, London, N.W.1. "An Exclusive Service" brochure issued by British Road Services, dealing with contract hire as provided by B.R.S. (CONTRACTS), LTD. and B.R.S. (PICKFORDS), LTD. Details and illustrations of 18 types of vehicles available are given.

Ball Bearing Equivalents. HOFFMANN MANUFACTURING CO. LTD., Chelmsford, Essex. Bearing symbols for ball and roller bearings of British (and some European and American) makers with their equivalent in the Hoffmann range, dimensions and B.S. symbol when applicable. 75 page catalogue.

Exploiting Natural Resources. HUNTING TECHNICAL SERVICES, LTD., 4 *Albemarle-street, London, W.*1. "92 Million More Mouths to Feed"—land use, reconnaissance, soil classification, range survey, forestry, geological and geophysical survey, building materials and groundwater; services undertaken by the company. Handsomely illustrated brochure.

Lighting. A.E.I. LAMP & LIGHTING CO. LTD., 18, Bedford-square, London, W.C.1. Complete catalogue of electric lamps and fittings including tungsten, infra-red, fluorescent, photographic, vehicle, and special purpose items. Separate catalogue for street lighting.

Hydrazine in Boiler Feed Water. WHIFFEN AND SONS, LTD., North West House, Marylebone-road, London, N.W.1. A general survey of the history of, and practical instructions for, the use of hydrazine for the de-oxygenation of boiler feed water. Technical brochure.

Hot-Blast Cupolas. CUPODEL LTD., 1294 Bristol-road South, Northfield, Birmingham, 31. Data respecting the savings and benefits resulting from the installation of recuperative hot-blast equipment in cupola-furnace plants. Illustrated descriptive booklet.

Fuel-Oil Additives. SLIP GROUP OF COMPANIES, 34 Great St. Helens, London, E.C.3. Description of furnace fuel-oil additives and of additives for use in slow-running and high-speed Diesel engines. Illustrated booklet entitled "The Furnaceman's Guide to Fuel Oil Additives."

Mechanical Handling Equipment. GEO. W. KING, LTD., Stevenage, Hertfordshire. Overhead-rail pulley blocks, conveyor chains, and grabs (for motor vehicle bodies, etc.). Illustrated specification sheets.

Rustless Flourescent Lighting Fittings. H. W. FIELD & SON, LTD., Station-road, Harold Wood, Essex. Cable trunking and other fittings for use with fluorescent lighting. Protected against rust by the use of I.C.I. Granodine. Illustrated leaflets.

Pocket Tool. J. STEAD & CO. LTD., Manor Works, Cricket Inn-road, Sheffield, 2. A new combination tool—screwdriver, pricker, and bradawl or file—the tools not in use being contained in the screw-top amber handle. Illustrated leaflet.

Industrial Lighting. HOLOPHANE LTD., Elverton-street, London, S.W.1. Lighting fittings for industrial applications. High bay, low bay, bulkhead and pendent fittings for plain or blended lights. Illustrated catalogue.

Junction Boxes. AUTOMATIC TELEPHONE & ELECTRIC CO. LTD., Strowger Works, Liverpool, 7. Multi-way light-current junction boxes for telephone or signalling systems. Leaflet.

Motor Control Gear. ALLEN WEST & CO. LTD., Brighton, 7. Air and oil-break starters, contactors and switchgear up to 11 kV, for marine, traction and industrial applications. Illustrated booklet.

Chemical Plant. W. C. HOLMES & CO. LTD., Turnbridge, Huddersfield. Range of products made by the firm including blowers, purifiers, washers and precipitators. Illustrated folder.

PRESSURE CONTROLLERS FOR PNEUMATIC SYSTEMS

A new range of seven slack-diaphragm-operated pressure controllers, all of the non-indicating, non-recording, blind-setting type, has been introduced by George Kent, Limited, Luton, Bedfordshire. Known as the FAF group. The range comprises suction or pressure controllers, including controllers for furnace pressures and differential pressures; also a special-purpose mill controller and an air-flow controller or differential-pressure transmitter. All the FAF instruments are suitable for wall, panel or post mounting, but normally the instruments are mounted near to the operating point.

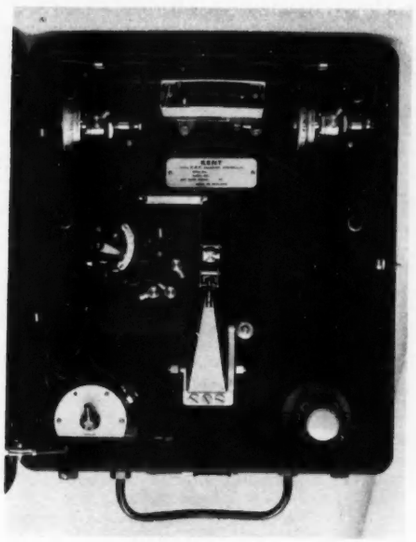
In the accompanying illustration, the edgewise gauge at the upper centre of the door shows the "supply" and "control" air pressures of the Kent Mark 20 controlling circuit, expressed as percentages between minimum and maximum range. Any one of a number of mechanisms in the Kent Mark 20 series of pneumatic-controlling units can be fitted in the instruments—proportional only, proportional plus integral, proportional plus derivative, or proportional plus integral plus derivative.

The FAF instrument case encloses an air-reducing valve, a relay, and an auto/manual switch. Where special testing and servicing facilities are required for the controlling unit, the instrument is associated with the Kent auto/manual/test/service and remote manual station. Where "overshoot" of the desired pressure value, following a period of regulator saturation, is likely to cause difficulty, and where integral action is used in the controlling unit, an automatic bleed unit and/or automatic injector unit are available for insertion in the control circuit, connected up as an integral-pressure desaturator, within the instrument case.

All the FAF instruments are designed to operate with the diaphragms in the mid-position, corresponding to a 9 lb. per sq. in. output of the 3 to 15 lb. per sq. in. controlling unit. The desired value setting of all the controllers is easily adjusted after opening the door of the instrument. The only maintenance required is the occasional removal of condensation from the filter sump of the controlling unit.

Furnace-Pressure Controller (*FAF* 1).—The special-purpose furnace-pressure controller can be set to control any pressure between $+\frac{1}{2}$ in. and $-\frac{1}{2}$ in. w.g. Usually one diaphragm side chamber is connected to the furnace combustion space and the other side chamber to the atmosphere at the furnace location. The atmosphere-piping connection follows the trail of the furnace-connection piping up to the point of entry into the furnace of the latter, thus compensating for any barometric-pressure changes and temperature changes in the connections to the controller. The instrument therefore behaves to some extent as a differential-pressure device, preventing the value of the effective controlled pressure in the furnace chamber from being spuriously affected by any difference in atmospheric pressure between the furnace location and the situation of the instrument. A deviation of $\pm\frac{1}{8}$ in. w.g. from the desired pressure value causes the instrument to move the plant regulator through its full travel. The desired-value setting is adjusted by loading the diaphragm's control spring by means of a knurled nut.

Static Suction or Pressure Controllers (*FAF* 2-7).—These are of two main types for values up to 6 in. w.g. and for values up to 48 in. w.g. A typical application of the low-range pressure controller (up to 6 in.) is for controlling gas-off-take pressure in automatic control systems for gas producers. In these instruments the pressure or suction is led to one side only of the main diaphragm, connected by a suitable linkage to the operating frames of the controlling unit. The ranges available are: 0 to $\pm 1\frac{1}{2}$ in. w.g.; 0 to ± 3 in. w.g.; and 0 to ± 6 in. w.g. The pressure change required for moving the plant regulator from its mid-way neutral position to the end of its travel is about half the maximum values given above. The setting is adjusted as in the furnace-pressure controller.



A slack-diaphragm-operated pressure controller from the Kent FAF range, comprising controllers for suction or pressure, differential pressure, furnace pressure and suction or pressure-type pulverising mills.

A subsidiary diaphragm chamber is employed in the up-to-48 in. w.g. controllers, one side only being connected to the pressure or suction. Linkage to the control spring and pneumatic controlling unit is by means of a lever. The ranges available are 0 to $\pm$ 12 in. w.g.; 0 to $\pm$ 24 in. w.g.; and 0 to $\pm$ 48 in. w.g. In other respects these controllers are similar to the low-pressure-range controllers.

Differential-Pressure Controllers (*FAF* 02 *to FAF* 07).—The division of ranges for the differential-pressure controllers is again up to 6 in. w.g. and up to 48 in. w.g., with sub-divisions (positive) as for the static-pressure controllers above. The construction is much the same as in the corresponding static-pressure instruments, except that both diaphragm side chambers are used, and they are adjusted in the same way. The maximum permissible static pressure is 2 lb. per sq. in.

Mill Controller (*FAF* 001).—The special-purpose mill-load controller, which is designed for the automatic load control of suction or pressure-type pulverising mills, has a differential pressure range of 1 in. to 13 in. w.g. The movement of the main slack diaphragm is modified by a subsidiary diaphragm. One diaphragm is for measuring 1 in. w.g. differential pressure, and the other up to 13 in. w.g. differential pressure. Normally, the pitot head on the mill is connected to one chamber, the static head at the inlet to the mill to another, and the static head at the outlet of the mill to the third pressure chamber. The maximum static pressure permissible with this instrument is 2 lb. per sq. in.

If h_1 and h_2 are the pressures led to either side of the main diaphragm, and h_3 the pressure led to one side of the subsidiary diaphragm, then the control value achieved is: $\dfrac{h_2 - h_1 \pm h_k}{h_3 - h_2}$ at any desired ratio between 1 to 5 and 1 to 35, where h_k represents a bias loading on the main diaphragm, applied by a spring which is adjustable to give a force equivalent to a head of from zero to 0·5 in. w.g., acting in a direction either to add to the effect of the differential pressure, or to subtract from it, as desired. The value of the ratio is adjusted by moving a fulcrum.

Air-Flow Controller or Differential-Pressure Transmitter (*FAF* 002).—This dual-purpose instrument has a range of 1 in. w.g./15 lb. per sq. in., the movement of the main slack diaphragm being modified by a bellows unit. When used as a controller, the instrument controls the quantity $h_2 - h_1$ referred to above, at a value determined by an input signal p to the air-operated bellows unit, varying between 3 and 15 lb. per sq. in. The relation between $h_2 - h_1$ and p is controlled according to a straight-line law, but the graph representing it does not normally pass through the origin, being displaced as required by the action of one or both of two bias springs which act respectively on the diaphragm and bellows movements. The relationship is expressed by the equation:—

$$\frac{h_2 - h_1 \pm h_k}{p - p_k} = C$$

where h_k is the differential head on the diaphragm to which the force of the diaphragm bias spring is equivalent, and can be adjusted between 0 and 0·5 in. w.g. in either direction; p_k is the pressure in the bellows to which the force of the bellows bias spring is equivalent, and can be adjusted between 0 and 8 lb. per sq. in. in either direction, and thus can be used if required to balance the 3 lb. per sq. in. starting value of the signal air pressure; and C is the constant for beam adjustment, with any value between 0·033 and 0·23.

Expressed in another way, for a maximum signal air pressure of 15 lb. per sq. in., with the bellows bias spring set to neutralise the initial 3 lb. per sq. in., the range of beam adjustment gives values of $h_2 - h_1 \pm h_k$ ranging from 0·4 in. to 2·75 in. w.g.

The instrument can be used as an air-flow controller, the desired value of which can be set by an air pressure fed into the bellows unit. It is also applied as a force-balance differential-pressure transmitter suitable for low-head measurement, providing an air signal proportional to the received differential pressure. In this instance the output from the Mark 20 controlling unit is fed back into the bellows unit to oppose the force produced by the differential pressure across the slack diaphragm. The controlling unit maintains the two forces equal so that the pressure in the bellows unit is accurately related to the differential pressure across the slack diaphragm, the instrument thus acting as a force-balance type of differential-pressure transmitter. The diaphragm casing is suitable for a maximum static pressure of 2 lb. per sq. in., and adjustment is as for the 1 in. to 13 in. w.g. mill controller.

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SUPERSONIC BOMBER FLIES

The B-58 Hustler supersonic bomber aircraft, built by the Convair Division of General Dynamics Corporation, Fort Worth, Texas, has made its maiden flight. It has been designed for the United States Air Force under the weapons-system concept—that is, Convair have been fully responsible not only for the design and construction of the airframe but also for procuring and installing all equipment other than the four General Electric J-79 turbojets.

For aircraft designed to fly through and above the speed of sound, Convair have pinned their faith solidly on the delta-wing configuration. The triangular wing of the B-58 Hustler, which is designed for supersonic speeds and altitudes above 50,000 ft., has a span of about 55 ft.; the overall length of the machine is about 95 ft., and it is about 30 ft. high to the tip of the sharply swept-back fin and rudder assembly. The four J-79 afterburning turbojets are mounted in nacelles slung below the wing. The fuselage is said to be waisted in accordance with the "area rule" to minimise transonic drag rise.

ELECTRONIC COUNTERS FOR INDUSTRY

PHOTO-TRANSISTORS USED FOR BATCH COUNTING

The new range of precision counting instruments for use in industry, developed by the electronics division of Dowty Nucleonics Limited, Brockhampton Park, Andoversford, includes a high-speed Dekatron counter; an electronic counter used in conjunction with an electro-mechanical high-speed register for counts up to 100 million; and high-speed counting equipment of particular interest in that it is used in conjunction with very small robust photo-transistor sensing units which can be inserted in places hitherto inaccessible to photo-electric detectors.

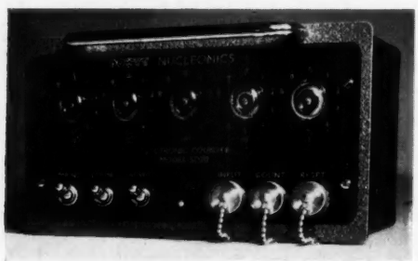


Fig. 1 The five-Dekatron counter counts up to 99,999 at rates up to 20,000 per second.

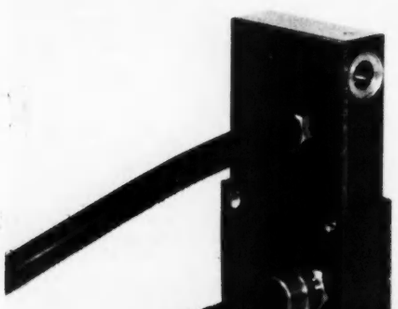


Fig. 2 The photo-transistor head of industrial counting equipment—identical in external appearance with the light-source head—comprises a potted Mullard photo-transistor encased in a Duralumin block and provided with an air blast to keep the lens free from dust. It is not much bigger than a large matchbox.

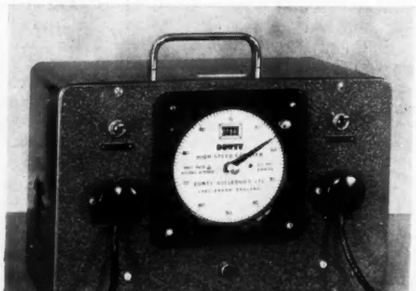


Fig. 3 An electromagnetic high-speed register with a valve-operated trigger circuit is used with the photo-transistor head shown in Fig. 2.

The high-speed five-Dekatron counter 5D20 illustrated in Fig. 1, which enables counts up to 99,999 to be taken at rates up to 20,000 per second, has been developed from the Dowty electronic tachometer, an application of which was on view at Farnborough and was described briefly in the September 21 issue of ENGINEERING, page 375. The Dekatron counter is intended for high-speed pulse counting both in the laboratory and for any industrial applications where it is desired to count or time high-speed events capable of being translated into electrical impulses as, for example, shaft revolutions or high flow rates. It can be used as a medium-speed scaling unit for the assay and analysis of radio-active materials, and a pulse amplifier/discriminator for this purpose is being developed.

The illustration gives little idea of the compact size of the unit—9½ in. by 5½ in. by 7 in. deep. If desired two such units can be installed side by side on a standard rack-mounting panel. Alternatively, front panels suitable for bench use or test panel are available. A separate power-pack unit can be plugged in to the back of the counter ,forming a self-contained unit or the power pack can be installed remotely from the counting unit.

Counting can be initiated by closing a switch on the unit, or through a remote socket, either by operating a switch or by a + 10 volt electrical signal. The counter can also be reset locally or remotely through the " reset " socket.

A front-panel socket provides for monitoring valve currents and voltages. Access to the valves and Dekatrons is by way of the front panel, and removable top and bottom panels give access to the circuit components. The counter operates on a mains supply of 200-250 volts at 50-60 cycles per second and consumes about 20 watts.

LONG-COUNT ELECTRONIC COUNTER

Where long counts as, for example, in endurance tests, are required, a two-Dekatron counter, used with a high-speed mechanical register, has been designed for industrial use. This instrument provides a maximum count of 100 million at a rate up to 5,000 pulses per second. It operates from 230 volt 50 cycle mains, and consumes about 100 watts. The Dekatrons indicate units and tens, and the high-speed register indicates hundreds. As in the more recent five-Dekatron counter already described, this instrument can be controlled either locally, or remotely by switch or by a 10 volt positive impulse. Resetting, however, is only possible by a switch on the counter unit itself. A modified unit is available where it is required to control the counter by successive pulses derived from an accurate timing source.

PHOTO TRANSISTOR UNITS

Dowty have also developed a photo-transistor unit for industrial counting equipment incorporating a Mullard photo-transistor and an electronic circuit which ensures that, irrespective of the way in which the light falls on the photo-transistor, the output of the unit is constant in pulse rate and amplitude. The unit is potted in epoxy resin, and to give the necessary robustness for industrial usage, the photo-transistor is embedded in a solid Duralumin block; an air blast is incorporated to keep the lens of the unit free from dust. The complete head is about the size of a large matchbox (4·1 in. by 2·125 in. by 0·89 in.) and gives a power output equivalent to that of a conventional photo-electric cell with a two-valve amplifier.

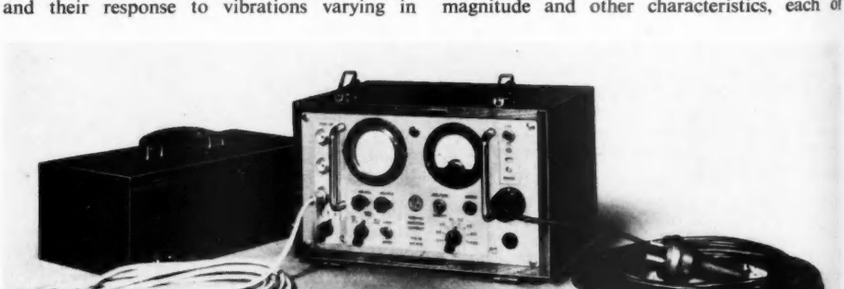
The industrial counting equipment comprises the photo-transistor head, a light source similar in external appearance to the photo-transistor unit, giving a parallel light beam ½ in. in diameter, and a high-speed counter with a trigger circuit. The unit will detect quite small items on production runs, down to about ¼ in. in diameter and spaced at about ½ in. intervals. Where larger items are to be counted, or for other reasons, the photo-transistor and light-source heads can be spaced apart at distances up to 24 in. The counting speed can be up to 75 counts per second, with no lower limit.

The high-speed counter employed is a production version of the company's well-established electromagnetic high-speed register with a valve operated trigger circuit. It counts up to 1 million and operates from a 230 volt 50 cycle mains supply, consuming about 40 watts. Its life, based on recent endurance tests at 50 pulses per second, is of the order of 100 million counts.

PORTABLE VIBRATION MEASURING EQUIPMENT

Until recently the engineer had only his sense of touch and his judgment to guide him in the evaluation and correction of vibration in rotating machinery. As, however, the detection and diagnosis of this phenomenon are becoming of increasing importance, a number of mechanical devices have been designed to give measurements of vibrations and, what is equally important, to allow comparisons to be made unaffected by personal opinions and human error. Mechanical pick-ups, however, have a low sensitivity and their response to vibrations varying in frequency is often inconsistent. The British Thomson-Houston Company, Limited, Rugby, have therefore designed an instrument, which is illustrated below, and will, it is claimed, provide information over a wide range of frequency and magnitude.

Before giving details of this instrument it may be recalled that the vibration of a running machine is often of complex form, the frequency of the main component of which is the same as that of the shaft. This component will have magnitude and other characteristics, each of



British Thomson-Houston equipment for measuring vibration in rotating machinery

In these simultaneous ejection tests from a Convair TF102A cockpit mounted on a track sled travelling at 240 m.p.h., the Rescu Mark 1 rocket-propelled seat is seen to be following a forward and upward trajectory, well above the conventional cartridge-actuated seat.

After separation of the dummy pilots from the seats, the canopy of the rocket-propelled dummy pilot (the upper one) opens more fully and his chances of reaching the ground in a favourable attitude appear to have been increased by the adoption of the new seat.

ROCKET-PROPELLED EJECTOR SEAT

Under development by the Convair Division of General Dynamics Corporation, San Diego, California, who have an air force contract to co-ordinate the development of a standard upward pilot-escape system for all the U.S.A.F. supersonic fighter aircraft, is a rocket-propelled ejector seat designed to permit pilots of Convair TF 102A combat trainer aircraft to escape safely even in a ground level emergency. The new seat, known as the Rescu Mark 1 seat, in fact combines a normal cartridge-actuated catapult with a rocket incorporated in the inner tube and brought into action by the cartridge catapult. It was constructed for Convair by Talco Engineering Company, Incorporated, Hamden, Connecticut, and has recently been subjected to its initial tests, when it was compared with a standard M3 cartridge-actuated ejector seat, at Edwards Air Force Base.

The two seats were installed side by side in a TF 102A cockpit and were provided with instrumented dummy pilots. The cockpit was mounted on a rocket sled on the track, and both seats were ejected in a slow-speed run (240 m.p.h.).

Although both seats parachuted safely to the ground, Convair state that the indications from these early tests are that rocket-propelled escape systems will ensure greater clearance from the aircraft, a reduction in the deceleration rate as the man-seat mass is catapulted into the airstream, and a greatly increased " on-the-deck " escape probability. In the initial tests, the Rescu Mark 1 had a much higher trajectory than did the M3 seat; and the parachute attached to the dummy propelled by the rocket seat opened more fully. The rocket drives the seat forward as well as up, thus " softening " the decleration as the pilot encounters the airstream. The build-up of acceleration is smooth and there is much less danger of spinal injury.

Dummy tests have also been carried out satisfactorily at a speed of 590 m.p.h., and future tests will be run at increasingly high Mach numbers. The attitude of the seats throughout the test is recorded by still, high-speed sequence and ciné cameras; in addition data is telemetered from three transmitters, two in the track sled, and one in one of the dummies recording wind blast, acceleration and deceleration. The entire rocket-sled ejection sequence takes less than 5 seconds.

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CORROSION-PROOF LAMP FITTING

For the many situations, both indoor and outdoor, where metal lighting fittings are subject to corrosion, the British Central Electrical Company, Limited, 6 and 8 Rosebery-avenue, London, E.C.1, have produced a unit which is claimed to be completely corrosion resistant. As may be seen from the illustration, it follows, in general, conventional designs.

The guard and suspension ring are made from mild-steel wire enveloped in polythene, $\frac{1}{4}$ in. thick. The reflector is of white alkathene. The lamp holder itself is nylon, and embodies solid-end contacts with the springs mounted behind them and therefore not carrying current. A flex lock for use with tough rubber cable prevents any strain being transmitted to the lamp holder.

Made from polythene, alkathene and nylon, this lamp fitting is claimed to be completely corrosion resistant.

which can be measured in a number of different ways. The equipment we are describing is designed to give readings of the total vibration together with comparative indications of the size and frequency of the principal components. These readings are obtained by showing the total vibration velocity or amplitude on a meter with a multiplying range switch. At the same time the vibration concerned is displayed on an oscilloscope tube with an adjustable time-base sweep frequency. The time base can be left running free, or it can be synchronised with the frequency of the vibration under test or the 50 cycle supply frequency.

As regards operation the vibration is measured by an electromagnetic pick-up of the " seismic " type. In this unit, a mass is spring mounted and constrained so that it can only oscillate in one direction. The natural period of this mass relative to the body of the pick-up is about 12 cycles per second. Above this frequency the mass remains virtually stationary in spite of the vibration of the pick-up itself. This is achieved by damping the mass with eddy currents induced in a copper ring moving in a magnetic field. The output of a coil on the mass and moving in the same field is then proportional to the rate of change of magnetic flux and therefore to the velocity of vibration. This may be regarded as constant for all frequencies above 12 cycles per second and can be converted into a direction vibration-amplitude reading by electrical integration.

In use the pick-up is either simply held against the vibrating body by means of the probe shown in the foreground of the illustration, or it can be clamped to the vibrating body. The vibration in any direction can be measured by changing the direction of the axis of the pick-up. The pick-up is usually connected to the instrument by a lead 25 ft. long but this may be increased to several hundred feet without affecting the response of the equipment. This response is, in fact, mainly limited by the frequency-response range of the pick-up, which is from 12 cycles to 1,000 cycles per second. The amplified gain has, however, been boosted so that the combined response is only reduced by about 25 per cent. at 10 cycles. On the most sensitive range a 10 per cent. reading on the meter corresponds to a vibration amplitude of 0·01 mil peak to peak (one mil equals 0·01 in.) or to a vibration velocity of 1 mil per second. There are eight ranges of measurement and on the least sensitive range the maximum reading is 20 mils amplitude or 2,000 mils per second velocity. The oscilloscope time base has a range of 10 to 100 cycles per second.

CONDITIONING AIRCRAFT CABINS

The philosophy of integration in aircraft design, in place of piece-meal applications of particular services, already in evidence in the latest thinking on flight instruments and flying control systems, is also being applied to the supply and control of cabin air flow, pressure and temperature. The new concept was presented in a lecture on "Air Conditioning in Aircraft," given recently by Dr. E. W. Still, Normalair Limited, before the Royal Aeronautical Society in London. The written paper falls into four main sections—a review of air-conditioning requirements, from the aspects of safety, weight, power, and passenger comfort; cooling systems of the air-cycle and vapour-cycle type; control systems for regulating cabin temperature, air flow, humidity, pressure, and oxygen supply; and laboratory test equipment for complete rig tests of air-conditioning systems.

Dr. Still's main point is that by centralising the various aspects of aircraft conditioning in the initial stages, a simpler and more effective system can be attained with considerable savings in weight. He considers that the reluctance of some aircraft designers to adopt high-voltage 400 cycle electrical systems in place of the traditional 28 volt direct-current system is limiting the possibiliities of saving weight in ancilliary systems; and so also is the necessity, with some types of turbine engines, of continuing to use the heavy engine-driven cabin supercharger instead of bleeding air directly from the engine compressor.

"The engine compressor bleed method of cabin pressurisation, together with the turbine-fan cold air unit, is easily the lightest and simplest way of cabin pressurising, and it is with some surprise that one still finds new designs of turbine engines . . . which do not make this provision . . . particularly important when it is appreciated that with the high altitude (30,000-45,000 ft.) of modern aircraft, the cabin compressor horse-power requirements are becoming very large indeed."

As a direct result of passenger complaints of unbearable cabin conditions while the aircraft is loading or taxying, vapour-cycle cooling is being added to all large new passenger aircraft to reduce the cabin humidity and to provide more effective cooling. This leads to the consideration of installing an auxiliary turbine power unit in the aircraft, which then makes possible the use of air turbine-driven engine starters in place of electrical starters, effecting an overall weight saving.

Referring to cabin pressurisation control, Dr. Still comments that there is a growing awareness that the differences between the military and civil requirements are not so real as at first thought. There is a trend towards reducing the degree of manual selection provided in civil aircraft; and it is being realised that the high rates of change of cabin altitude now permitted in miltary aircraft are having a bad effect on the crew. The alternatives of providing, for military aircraft, a high differential pressure at altitude, or a negative differential pressure at the bottom of a dive, will pose new structural problems for designers.

The provision of oxygen in addition to cabin pressurisation is a requirement for military aircraft, among other things to protect the crew should the cabin be punctured by enemy action. For civil aircraft, the British airworthiness authorities do not require the provision of an oxygen system; but in America, air liners flying at over 45,000 ft. may be required to have emergency oxygen laid on to every passenger seat to cover flight from the point of no return, and the Boeing 707 and Douglas DC8 will be so provided.

We give below an abridged version of the section of Dr. Still's lecture dealing with cooling systems.

COOLING SYSTEMS FOR AIRCRAFT

There are two main types of cooling systems in use, the air-cycle system and the vapour-cycle system. The air-cycle system relies for its cooling on supplying air from a high-pressure source to an air turbine, and by causing the turbine to do work such as driving a fan or a compressor. The vapour-cycle system achieves its cooling effect by transferring—from the air to be cooled—the heat energy necessary to evaporate a liquid refrigerant.

Typical performances of cold air units, designed in various sizes to cool compressed air after initial cooling by a heat exchanger, are given in the Table below. The heat exchangers used are of light-alloy brazed construction and are designed to give a thermal efficiency of at least 80 per cent. To achieve such an efficiency it is essential to have a ram air flow approximately three times that of the cabin air.

Type	10 lb. per min.	25 lb. per min.	55 lb. per min.
Weight ..	1·7 lb.	4·5 lb.	11·75 lb.
Air mass flow	10 lb. per min.	20 lb. per min.	62 lb. per min.
Temperature drop across turbine ..	119 deg. C.	130 deg. C.	119 deg. C.
Pressure ratio	7·2 : 1	7·1 : 1	2·6 : 1

Air-cycle cooling systems can be in one of three forms. In one, the cold-air unit is used on the "bootstrap" principle; in another it is used as a turbine fan; and in the third case the cold-air unit can be applied on the regenerative-cycle principle.

The Bootstrap System.—This, the first to be used, was evolved for aircraft employing piston engines for propulsion. The pressure rise across the engine-driven blowers in this case is relatively low, so that insufficient cooling would be caused by passing the air through a turbine. By making the turbine drive a compressor used to compress further the air from the engine-driven blower, and then passing the further-compressed air through the cooling turbine, a sufficiently high pressure ratio across the cooling turbine is achieved, giving a much greater temperature drop across the turbine. An intercooler, placed in circuit between the compressor and the turbine, cancels out the heat gain arising during the second stage of compression. A heat exchanger or pre-cooler is, of course, employed between the engine-driven blower and the turbine-driven compressor; both heat exchangers being cooled by ram air. The cooling effected by the turbine, i.e., the refrigeration, is brought about fundamentally by the work done by the turbine in driving its compressor.

There is a limit to the amount of cooling that can be applied by such a system due to the frosting of the air outlet ducts if the turbine-outlet temperature is taken to the freezing point. Problems of water separation also arise. The minimum air pressure ratio consistent with cabin pressurisation and cooling needs should be used if the engine-driven compressor horse-power is not to become excessive.

One fault of the bootstrap system is that very little cooling is available on a stationary aircraft, owing to the absence of ram in the two heat exchangers.

The Turbine Fan System.—Progress from piston to turbine engines, with the associated increase in engine air-compressor pressure ratios, and the availability of large quantities of air, have resulted in a change of cold air-unit design. There is now usually sufficient air pressure available from the engine compressor at a high enough pressure not only to pressurise the cabin, but to provide the energy for cooling.

This system comprises a heat exchanger which supplies the initial cooling of the air from the engine compressor, which is much hotter than that obtained from engine-driven compressors. The air passes from the heat exchanger to the air turbine, and the refrigeration is provided by making the turbine drive a fan or ejector pump compressor; either of which can be made to boost the flow of coolant ram air through the heat exchanger. This system does provide some degree of ground cooling as long as the engine is running, even though there is no flow of ram air through the heat exchanger. No intercooler is required, thus effecting a great saving in weight; also the heat arising from the compression is passed overboard.

Whilst discussing the tapping of turbine-engine compressors for cabin-pressurisation purposes, it must be mentioned that, owing to the fear of air contamination by oil, etc., American designers are using a cabin compressor which takes the air from the aircraft leading edge, and passes it through a centrifugal compressor and into the cabin. The compressor is directly driven by an air turbine which is supplied with air from the engine compressor bleed, but this "contaminated" air is then spilled overboard. It should be clearly stated that this system has not been found necessary where British engines are employed, owing to the very efficient compressor bearing seals.

Figs. 1 and 2 indicate in simple diagram form the layout of these two methods of applying cold air units, and also show the approximate temperatures and pressures associated with such systems.

The Regenerative Cycle System.—Heat exchangers will cause considerable drag if they are to be ram-air-cooled at aircraft Mach numbers from 1 to 3—apart from the problem associated with ram temperatures at such speeds. Also, for military purposes, altitudes well above 45,000 ft. have to be considered, under which conditions there is not much air

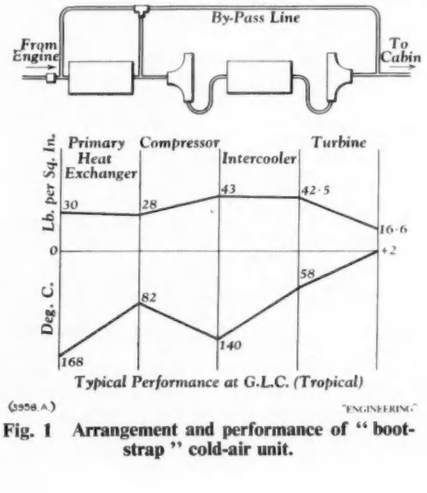


Fig. 1 Arrangement and performance of "bootstrap" cold-air unit.

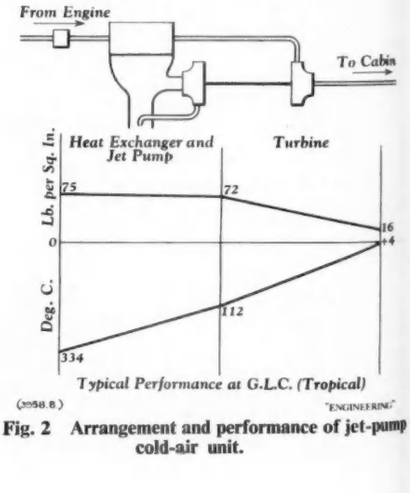


Fig. 2 Arrangement and performance of jet-pump cold-air unit.

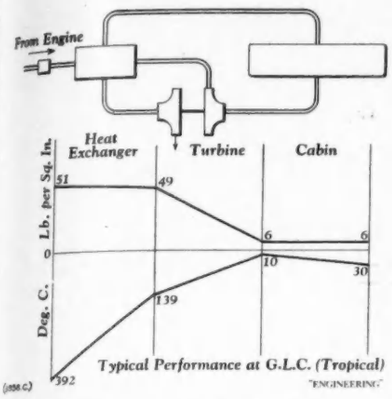


Fig. 3 Arrangement and performance of regenerative-cycle cold-air unit.

simple air-cycle system can be modified by placing a water boiler between the ram-air heat exchanger and the turbine. It is most important that water is only boiled off when really necessary, such as for high-speed bursts. The water tank must therefore be heat-insulated and the water fed into a flash boiler as required, or the tank and boiler can be combined and the air normally diverted through a by-pass and only put through the boiler when necessary.

Water has the highest latent heat of any liquid but even at altitude its boiling point is too high to be used in the cabin. Ammonia has a latent heat of 341 C.H.U. per lb. at an atmospheric boiling point of − 33·5 deg. C., and a critical temperature of 130 deg. C. At a cabin temperature of 25 deg. C. its latent heat would be about 230. If a bottle of liquid ammonia could be carried and used to feed a boiler directly, through which cabin air is circulated by a fan, then all the latent heat of about 230 C.H.U. per lb. would be usefully employed in cooling the cabin instead of only a fraction of the latent heat of the water and air

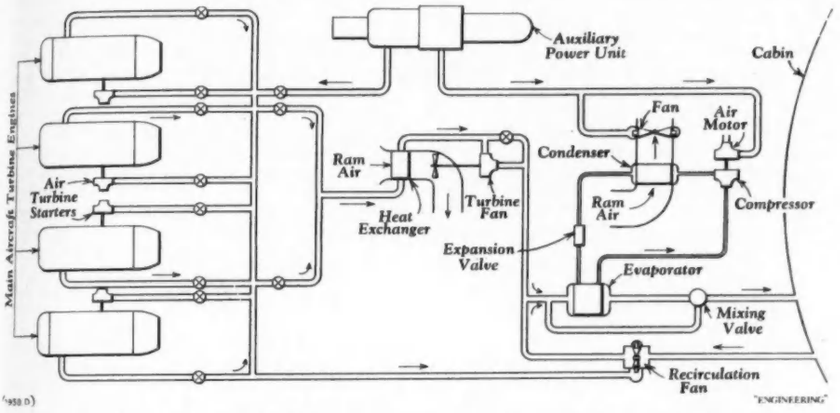


Fig. 4 Air conditioning system fed by compressor bleed air, incorporating an auxiliary power unit and vapour-cycle cooling.

available for cooling in any case. These factors have led to the development of the regenerative systems which can employ either fan or bootstrap types of unit.

In principle, in the regenerative cycle system, cabin air is bled from the engine compressor and passes through an air-to-air heat exchanger, then through the turbine of the cold-air unit and finally into the aircraft cabin.

The discharge air from the cabin is not thrown overboard as in the two earlier cases; it is passed through the heat exchanger and is finally discharged through a nozzle to obtain the maximum use of the energy left. Fig. 3 shows the layout of the system together with the temperature and pressure distributions. For a given pressure and temperature of the air bled off the engine, all the available energy has been extracted from the air before it is finally thrown overboard, and also ram heat-exchanger losses have been eliminated. This system is particularly applicable to small military aircraft.

VAPOUR-CYCLE COOLING

The open-circuit vapour-cycle cooling system, which evaporates the fluid directly to the atmosphere is extremely light and simple but loses the weight of the refrigerant. Water is by far the lightest fluid for this purpose, but it must be supplemented by a cooling turbine because its boiling point is too high. This is still true at 70,000 ft. where its boiling point is 28 deg. C.

The nearest competitor is ammonia, but even in the short-range aircraft this still comes out heavier than air-plus-water, and has the disadvantage of being corrosive and poisonous. Oxygen, nitrogen, and liquid air are all much heavier per ton of refrigeration, and to supply 15 tons for 3½ hours would require 3,500 lb. of liquid air, which is several times the weight of the closed-circuit vapour-cycle system.

For short-endurance supersonic aircraft a turbine system. Thus under some flight conditions the weight of a direct-cooling ammonia system could be less than that of a water system. In practice the ammonia system is used in missiles but has not yet been applied to aircraft.

For the long-range Mach 2 or 2·5 aircraft, and also to a certain extent for shorter-range aircraft and missiles, the closed-circuit vapour-cycle refrigeration system is the most practical. Suitable refrigerants are the halides—fluoro-chloro-methane compounds such as Freon, Carrene, Genetron, Isotron, and Arcton. A vapour-cycle refrigerator is in effect a heat pump. It lifts heat from one temperature level and rejects it at a higher level. The work needed to operate the heat pump depends on the difference in temperature levels of the cycle. Where the temperature difference is small it may be only one-third or one-quarter of the heat lifted, but where the temperature difference is large the work input approaches the heat extracted from the low-temperature source. For any refrigerant there is a limiting temperature range over which it can be used.

For passenger aircraft the vapour-cycle system is being adopted for cooling the aircraft while on the ground. For the 100 seat passenger aircraft it has been found that 12 to 14 tons of refrigeration is required on the ground. This needs about 25 h.p. and provides a good illustration of the weight saving achieved by using either alternating-current power or air bleed instead of direct-current power. Two direct-current 12 h.p. motors driving duplicated reciprocating compressors, including their separate systems, with circulating and condensing fans, weigh 390 lb., while a single alternating-current motor centrifugal compressor giving 12 tons refrigeration weighs 150 lb. as a complete system, and the corresponding air-turbine compressor system weighs 140 lb. or less.

The ground power requirements of such systems, however, severely strain the existing equipment, and this, together with the weight reductions possible from the use of air turbine-driven engine starters, makes the possible use of airborne auxiliary power units attractive.

The weight reduction is sufficient (including the saving on busbars) to cover the installed weight of the auxiliary power unit, which can provide the bleed air for engine starting and for driving the vapour-cycle compressor, and can drive any emergeny equipment required. It makes the aircraft independent of ground starting trucks and provides emergency power at high altitude.

A possible arrangement of an air conditioning system fed by compressor bleed air, and incorporating an auxiliary power unit and vapour-cycle cooling, is shown in Fig. 4.

The following table compares such a system using an auxiliary power unit with a system that does not have an auxiliary power unit and which has only 28 volts direct current as the power source.

Weight Summary for 100 Seat Aircraft
(Comparing Bleed with No Bleed plus D.C. Electrics)

System details	Jet engine with bleed	Jet engine no bleed, 28 v. D.C. electrics
	lb.	lb.
Cabin pressure system	50	50
Heat exchangers ..	100 primary	200 primary plus secondary
Air-cycle refrigeration	40 turbo-fan	45 bootstrap
Vapour-cycle system	149 air turbine driven	240 reciprocating 28 v. D.C. motor
Engine starting ..	104 air turbine bleed	400 including busbars
A.P.U. (GTCP.85) ..	215	Nil
40 kVA	80 alternator	140 D.C. generator
Installation ..	125	Nil
Engine driven compressors	Nil	200 (2 off)
Total weight, lb.	863	1,275
Cooling tonnage:		
Air cycle	18	18
Vapour cycle ..	12	6
Ground cooling ..	Self-contained	From ground truck

★ ★ ★

CHEMICALLY RESISTANT BARREL PUMP

A new portable electric barrel pump has been introduced by the British Central Electrical Company, Limited, 6 and 8 Rosebery-avenue, London, E.C.1, suitable for use with most acids, alkalis and other liquids that have previously been beyond the scope of the standard barrel pump.

The pump is known as the 300 SR. The motor housing is manufactured from aluminium alloy, as in earlier barrel pumps, but the lifting tube and all metal parts which would normally be in contact with the liquid being pumped are manufactured in stainless steel, containing a high percentage of chromium. This material resists the attack of sulphuric and silicic acds amongt others, and the pump is suitable for handling many chemicals.

The new pump is self-priming and has a lifting tube 3 ft. 11 in. long and 1⅛ in. in diameter. It is thus suitable for insertion in standard acid containers. The output is approximately 1,600 to 2,000 gallons per hour when working against a 12 ft. head.

Models are available for 42 volt, 110 volt, and 240 volt direct-current and single-phase alternating-current operation, the consumption of the motor being 260 watts. The 300 SR portable barrel pump is not intended for use with inflammable liquids or in hazardous situations, and will not be submitted for flame-proof certification.

Whilst stainless-steel accessories are not, at present, available, plastics hose or sweetened hose for use with consumable liquids, can be supplied; also hose for special applications, such as use with concentrated acids, etc.

ADVANCED POWER REACTORS

1—TOWARDS HIGHER OUTPUT AND EFFICIENCY

To-day, at Harwell, the United Kingdom Atomic Energy Authority are holding a conference at which their programme of research on advanced types of nuclear power reactors will be explained to representatives of British industry. This programme depends to some extent on the materials testing reactor DIDO, which was officially inaugurated by the President of the Royal Society, Sir Cyril Hinshelwood, last week. It is therefore an appropriate time to discuss the direction which reactor development is taking. The following article is based generally on talks given by Sir Edwin Plowden and Sir John Cockcroft at a recent meeting of the International Bank for Reconstruction and Development, and on papers presented by Sir Christopher Hinton and Mr. R. V. Moore at the "Symposium on Calder Works Nuclear Power Plant" held last Thursday and Friday by the British Nuclear Energy Conference. (The symposium papers and discussion will be printed in full in the April and July, 1957, issues of the Journal *of the B.N.E.C.) The present article begins with a brief discussion of general trends and then deals in greater detail with developments in the field of gas-cooled reactors. In a later article we hope to discuss the very-high-temperature gas-cooled reactor and to compare certain other reactor systems.*

In design as in exposition, it is always necessary to go from the known to the unknown. Thus, Calder Works, a novelty of technical achievement, is based on engineering principles which have been long familiar. The reactor pressure vessels, for example, owe something to wind-tunnel construction, and the heat exchangers to conventional boiler practice. But eventually, techniques, methods and materials must be adapted to the special requirements of the new process. Reactor technology is in an early stage of technical development and as such is of broad interest, since it embraces all the main engineering disciplines, civil, mechanical, electrical and chemical, and since, in addition, many problems remain to be solved. Moreover, given a basic knowledge of reactor principles (the chain reaction, the use of moderators and the action of coolants), the virtues and disadvantages of any reactor system are easily appreciated, though the task of comparing several systems technically or economically is necessarily complex. Thus there is much in favour of developing a tried system, which is known to be practicable. Chosen originally in this country because vast quantities of pure cooling water were not available and because of its inherent stability, the gas-cooled reactor offers the best immediate prospect in Britain, and it is thought that, even at a later date, it may in modified form prove competitive with such advanced designs as the sodium-cooled graphite-moderated system. But in any case a properly balanced nuclear economy requires a number of different systems to be operated concurrently.

Considerable technical advances have already been made since the Calder Hall plutonium plant and power station was designed, and it seems likely that the gross power output of the initial stations will exceed that of Calder Hall "A" by a factor of three with little increase in cost. Thus, instead of 92 MW the electrical rating of the first Central Electricity Authority stations may be as high as 300 MW, and the capital cost per kW less than £120, though the initial investment of fuel may be about £30 per kW. Coal stations cost some £55 per installed kW. In addition, operating temperatures of early stations are likely to be low (in the region of 400 deg. C.) and the thermal efficiency only a little more than 25 per cent. Burn-up of uranium fuel in these reactors is likely to be about 3,000 megawatt-days (MWD) per tonne, (coal equivalent: 10,000 tons per ton of uranium). Plutonium will be produced, which may serve as enrichment for the fuel of future power reactors, and it is thought that a reasonable credit to allow for it is about 0·1*d.* per unit of electricity sent out. Its value, however, will depend to a great extent on the development of convenient means of extracting it from irradiated fuel elements and re-processing it. Owing to its toxicity, handling too presents a major problem. (Plutonium, incidentally, if burnt completely would yield the same energy as 3 million times its weight of coal.) From these figures and the fact that coal costs about £4 a ton and uranium ore about £10,000 a ton, it has been estimated that power from the projected stations will cost about 0·6*d.* a unit or 7 mills (one mill = 0·001 dols.); they will thus be roughly competitive with coal-fired stations.

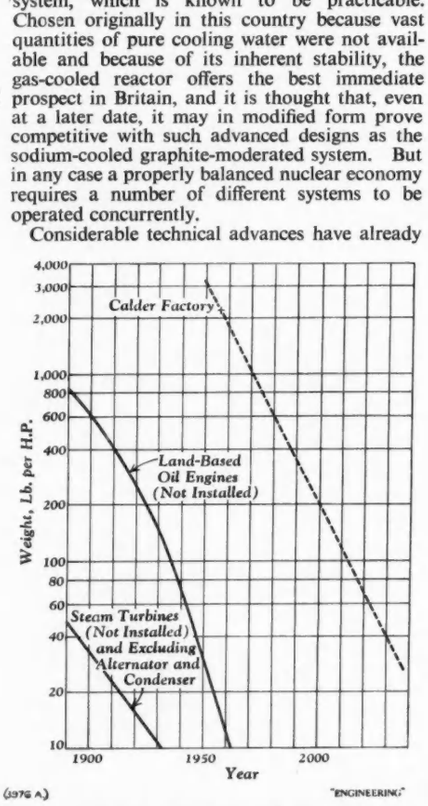


Fig. 1 Comparison of steam turbines, land-based oil engines and Calder Works in terms of weight per unit output. By analogy the power-weight ratings of future nuclear stations may be obtained.

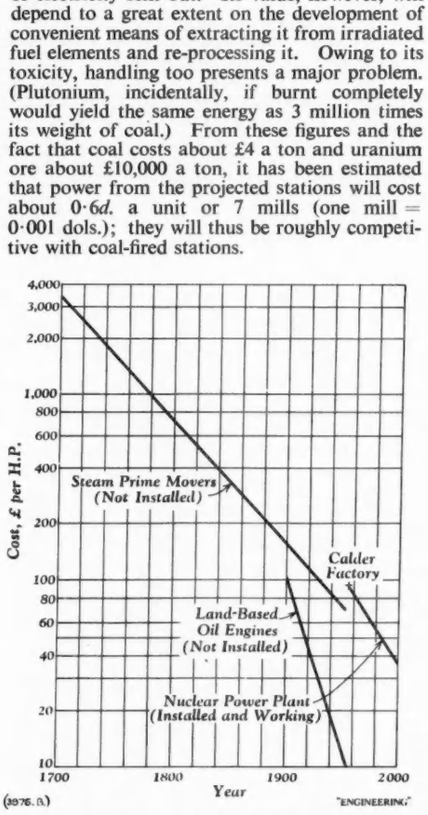


Fig. 2 Comparison of 1954 equivalent cost of steam prime movers, land-based oil engines and Calder Works, showing possible future trends in the capital cost of nuclear power plant.

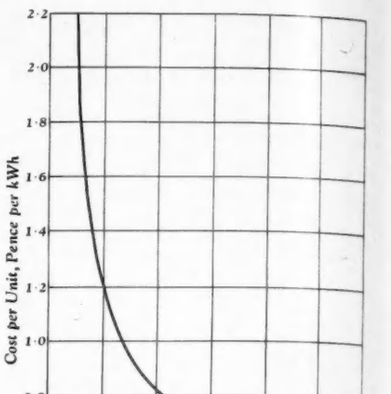


Fig. 3 Cost of power per unit sent out as a function of fuel burn-up in megawatt-days per tonne. Results are for a reactor with a capital cost of £125 per installed kW, operating at 80 per cent. load factor and an efficiency of 25 per cent.

ECONOMIES OF SCALE

It is important to point out that with nuclear power stations there are great economies of scale, and though with later reactors using enriched fuels this may not be so true, they are likely to be economic first in the larger sizes. Thus, in the early stations the advance beyond Calder Works is due not only to the changed emphasis from plutonium to power production, but also to an increase in reactor size. This has been made possible by increased thickness or strength of reactor pressure vessel. Increase in reactor size gives higher heat output since the neutron flux can be flattened (see Atomic Review last week, section on "Reactor Output," page 669), and since the maximum rate of heat removal can be associated with a larger volume of core. Increased vessel thickness also makes possible a rise in coolant-gas pressure (perhaps 150 lb. per sq. in. as against 100 lb. per sq. in. for Calder Hall) and hence increased efficiency of heat removal, or reduced circulating costs, though with diminishing returns as pressure increases. In addition, capital costs increase but to a smaller extent as the core size is increased. Other improvements may result from the use of slightly higher gas outlet temperatures made possible by improved canning material (a zirconium alloy instead of Magnox, for example) and consequently enhanced thermal efficiency. Subsequently, by use of a beryllium-alloy can, it may be possible to raise fuel-element temperatures by about 100 deg. C. Thus, by 1965-heat ratings may have increased by a further factor of two and the capital costs of nuclear stations (neglecting their advantage in fuel costs) be little more than those of coal-fired stations.

IMPROVING BURN-UP

Though canning costs are likely to be higher, this may be offset by a fall in the primary cost of uranium. However, the main prospect of reducing fuel costs is by increasing burn-up. One method is by re-cycling the plutonium produced, thereby supplementing the depleted uranium 235. Another is to burn the plutonium where it is formed within the element; this seems likely to require the use of ceramic fuel elements but a burn-up of 10,000 MWD per

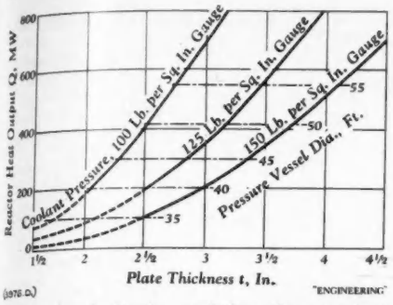


Fig. 4 Graph showing variation of reactor heat output with coolant pressure, pressure-vessel diameter and vessel plate thickness.

tonne or 30,000 tons of coal equivalent per ton of uranium may be achieved.

It is apparent that by 1963-64 by-product plutonium will be produced in substantial quantities and, depending on the cost of separation processes, will probably be cheaper than uranium 235 produced in diffusion plants. Moreover, use of plutonium means conservation of nuclear fuels since the bulk of the natural uranium then becomes usable. It appears that plutonium may be profitably used in at least four ways. These are:

(1) It could be used in new thermal reactors requiring initial enrichment by re-cycling, for example, high-temperature gas-cooled reactors. These will be considered in a later part of the article.

(2) It could be used in fast-neutron, breeder reactors operating on a plutonium-uranium 238 cycle and producing power. This leads to balanced fast and thermal reactor schemes in which a comparatively large fraction of the uranium 238 is used, arising from the fact that fast reactors breed more fissile material than they consume. An experimental fast reactor is currently under construction at Dounreay, in the north of Scotland.

(3) It could be used in fast or thermal reactors as the fissile material for a plutonium-thorium "transition cycle" producing power and uranium 233 as a by-product. The uranium 233 might subsequently be used in a self-sustaining uranium 233-thorium cycle in thermal reactors, if these prove practicable, or might be used as the fissile material in fast reactors, breeding from uranium 238 or thorium.

(4) It might be used in power plants requiring highly enriched fuel, for example, plants designed with a large power-to-weight ratio.

Studies of other systems are in progress. For example, loops are to be inserted in DIDO concerned with the following reactor types: water-moderated reactors, high-temperature gas-cooled reactors, aqueous homogeneous reactors, reactors using uranium-bismuth slurry as fuel and organic-moderated reactors. Organic-moderated reactors are likely to use a liquid, diphenyl, as moderator and are thought to offer considerable advantages in view of the low system pressure at which they can operate. Work is also being carried out on the sodium-graphite system, though its economic advantage over advanced gas-cooled reactors may not prove substantial. The boiling-water reactor in various forms (see Atomic Review last week) is also believed by some to offer the prospect of high efficiencies. Many of these require enriched fuels and may be competitive with conventional power plants in quite small sizes. Certain of them will be compared in a later article. The homogeneous system may achieve very high heat ratings and improved heat transfer, since fuel and moderator are intimately mixed, thereby effecting better contact between fuel and cooling medium. In addition, improved burn-up may be obtained since there will be regeneration of fuel within the reactor. It is therefore an important long-range prospect and the means whereby power at 0·4*d.* or 0·5*d.* per unit (competitive with hydro-electric power) may eventually be achieved. This, however, is still at least 10 or 15 years away.

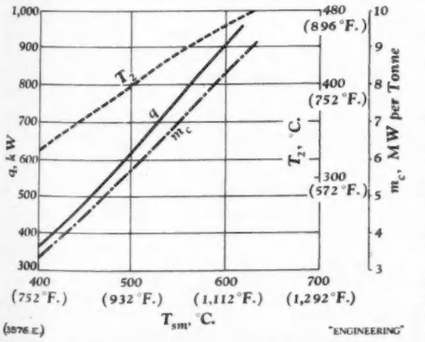


Fig. 5 Variations of channel heat rate *q*, channel gas outlet temperature T_2 with maximum fuel surface temperature. Fig. 6 shows effect on efficiency.

FALLING CAPITAL COSTS

Another method of computing the future cost of power from nuclear reactors is by historical analogy. Past experience tells us that the weight per horse-power and capital costs (in terms of real money per h.p.) fall with the passage of time for all types of prime mover. This is indicated in the graphs shown in Figs. 1 and 2. Fig. 1 plots against time the weight per h.p. of land-based oil engines and of steam turbines and shows the progressive decrease in weight per h.p. which accompanies the development of better materials of construction and better techniques of design. On this graph appears a curve which assumes the same general characteristic for the weight per h.p. of land-based nuclear power plants, and a study of this curve is interesting because it gives some indication of the date at which the weight per h.p. of economical nuclear plants can be expected to fall to levels at which such plants may be installed economically on moving platforms. The second chart gives the cost per h.p. of steam prime movers and of land-based oil engines and again gives an imputed curve for the capital cost of nuclear power plants. From the White Paper it is possible to deduce a capital cost per kW of £125 for the earlier power stations of the Calder Hall type and this is used as the starting point for the curve on Fig. 2. It must, of course, be recognised that the curves in Fig. 2 are not strictly comparable, because the cost for the nuclear power plant includes the civil engineering work; this has been done because much of the civil work (such as the biological shield) is an integral part of the installation and cannot be separated from other civil engineering work on the station. In addition, it might be noted that the higher the stage of technical development, the more technical knowledge there is for a new technology to adopt. High-temperature materials, for example, have been developed for gas-turbines and may also have given a lead in reactor metallurgy. Nevertheless, the historical comparison is a fair one, and although the curves are not strictly comparable, Fig. 2 is useful in showing trends.

Reduction in capital cost in accordance with the hypothetical curve shown in Fig. 2 would give in 1975 a cost per unit of 0·5*d.* and this takes no account of reduction in cost of the ancillary processes (such as chemical extraction) which might also be expected. This tallies with the estimate mentioned earlier, based on the homogeneous reactor. These improvements in capital cost should be seen in the light of the fact that, whereas in a conventional power plant roughly three-quarters of the cost per unit sent out represents fuel and operating costs and only one-quarter capital charges; in a nuclear station capital charges account for nearly two-thirds of the costs. The effect of reduced capital charges per unit is thus very important. Some indication of the part played by capital charges in the total cost per unit sent out at Calder Hall is given by Table I.

TABLE I. *Cost per Unit of Power Sent Out from Calder Works*

Cost component	Cost	
	d.	Per cent.
Capital charge	0·56	53
Fuel inventory charge	0·10	9
Fuel consumption charge	0·35	33
Operation and maintenance	0·05	5
Total	1·06	100

It is of interest that at present the cost of electricity sent out by conventional stations per unit is about 0·6*d.* whereas the cost to the consumer is roughly 1·4*d.* per unit. Thus 0·8*d.* of the total, which corresponds to distribution and other charges is outside the scope of the nuclear engineer.

LONGEVITY OF PIPPA

In the opinion of Sir Christopher Hinton, the merits of the Calder Hall type of reactor and the partial improvements that can be made in its design are such that plants of its kind will still be built 25 years from now, and will alone enable us to retain our present lead for at least a decade. In the second half of that 25 year period, however, it will be replaced in certain land-based applications by reactors of higher rating and in the very long term it will, for most purposes, be superseded by such reactors. Reduction in weight per h.p. beyond a certain point will not be possible with the use of gaseous coolants; to get further we must achieve the higher ratings which can only be achieved by employing liquid coolants. The use of these coolants at present is not industrially practicable because they involve technological problems which have not been solved; they demand materials which are not in commercial supply; or they call for the use of enriched fuel. In time these problems will be overcome, and highly rated reactors using liquid cooling will be employed; first, in those special applications where the user can afford to pay inflated prices for reduced weight per h.p. and then, as the cost of the special materials demanded falls with increasing experience of their production, for normal industrial applications.

GAS-COOLED REACTORS

The remainder of the article will be largely concerned with one class of reactor, that based on the gas-cooled graphite-moderated system. In considering the developments which this system may undergo, it will be seen, for example, that a new range of gas-cooled reactors becomes possible with the introduction of fuel elements having increased surface-to-mass ratios and clad with an alloy of high melting point. Such reactors will probably need initial enrichment, although their design may enable them to operate on re-cycled fuel with a natural-uranium feed. The higher heat ratings which may thus be obtained should extend their application beyond base-load power stations to plants producing small quantities of power at a worthwhile cost. In addition, still higher temperature systems may be developed in which metals

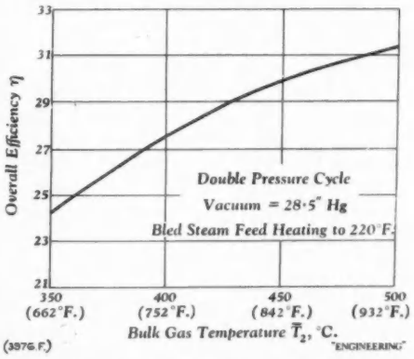


Fig. 6 Effect of bulk gas outlet temperature (from reactor core) on overall thermal efficiency.

would be excluded from the core and use be made of ceramic fuels dispersed in the graphite moderator. Reactors of this kind may lead to the economic use of gas-turbine cycles and the elimination of intermediate heat exchangers. These and other possibilities are discussed in greater detail below.

As a starting point we may consider a nuclear power station costing £125 per installed kW, operating at 80 per cent. load factor and 25 per cent. efficiency. It should be observed that the plant availability necessary to achieve a high load factor demands means of fuel-element charging and discharging superior to those at Calder Hall. Fig. 3 shows the cost per unit sent out as a function of fuel burn-up in megawatt-days (MWD) per tonne of uranium, priced at £20,000 per tonne. The fuel elements are assumed to have no residual value. It is clearly important that the fuel should be capable of as long a period of irradiation as possible before the accumulation of fission products inhibits the chain reaction, particularly up to about 2,000 or 3,000 MWD per tonne. The ability of a natural-uranium charge to achieve a long irradiation depends mainly on two factors; first, the neutron balance, necessary for the chain reaction, must be maintained, and secondly, the fuel elements must withstand the effects of irradiation damage under the operating conditions, without an excessive number of failures. As the uranium 235 content of the charge is consumed, it is replaced to some extent by plutonium formed from uranium 238 by neutron capture, and a small fraction of the plutonium so formed is itself fissioned. Recent experimental results from the Calder plant tend to confirm that 3,000 MWD per tonne is obtainable before the chain reaction ceases. The metallurgical limits on the life of the fuel elements arise from the tendency of uranium to increase in volume when irradiated at temperatures approaching the alpha-beta change point of 600 deg. C. Indeed, it is likely that 3,000 MWD per tonne may be exceeded and the operating temperature raised by the adoption of certain alloys of uranium stabilised in the gamma phase.

FLUX FLATTENING

We have already discussed the effect of increasing pressure-vessel strength and thickness but this may be underlined by considering a graphite core, with the uranium channels located on a square lattice, surrounded by a graphite reflector 3 ft. thick within a cylindrical pressure vessel, with 1 ft. radial clearance between the inside of the pressure vessel and the graphite. It can be shown that

$$Q = \frac{0{\cdot}113\,(d_p - 8)^2\, q\, \alpha}{p_s{}^2}$$

where Q is the heat rate of the reactor in MW ; q the heat output of the most highly rated uranium channel; d_p the internal diameter of pressure vessel in ft.; p_s the pitch of uranium channels in in.; and α the radial form factor of neutron flux, mean to maximum.

Since Q increases with α, the effect of flux flattening is marked. In the Calder Hall reactors, which are just supercritical at full power, there is necessarily greater reactivity at the centre of the core than at the periphery, so that the heat rating of the fuel channels varies considerably across the reactor. By increasing the core diameter well above that required for criticality and suitably introducing neutron-absorbing material, or rearranging the fuel-channel spacing, or using enriched fuel in certain channels, a comparatively uniform flux distribution may be obtained (flattening). Thus a greater number of fuel channels may be operated at heat ratings approaching the maximum permitted by considerations of temperature and rate of heat removal. Heat removed can itself be increased by raising the system pressure, but to a diminishing extent as pressure increases. Coolant pressure necessarily depends on pressure-vessel thickness, which also, of course, governs reactor size and hence the degree of flux flattening and the total volume of core associated with heat production.

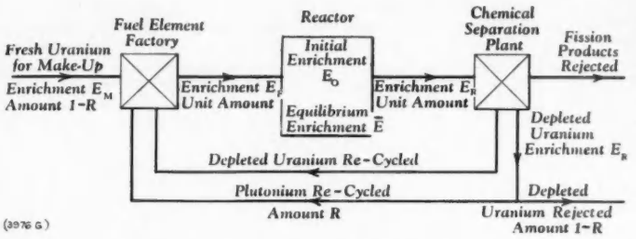


Fig. 7 Flow diagram for fuel re-cycling process. In this way it is possible to reduce demand for natural uranium and to provide a source of enrichment other than uranium 235.

These quantities are related in the graph shown in Fig. 4. Increases in coolant pressure should, of course, be considered in connection with the pumping power required as a percentage of reactor heat output. Reduction in lattice pitch, p_s, also clearly brings an advantage but squeezing beyond a certain limit introduces mechanical and nuclear problems.

TEMPERATURE AND CLADDING

Raising operating temperatures is also a source of improvement, since both heat output and thermal efficiency will be increased, though the cost of fabricated fuel elements may offset this to some extent. Fuel-element cladding material should be of low neutron cross-section and is used to prevent escape of fission products and chemical reactions between uranium and coolant. Some possible materials are listed in Table II; stainless steel is included though its poor neutron efficiency makes it unsuitable. In addition, it can be seen that beryllium, niobium and zirconium, though withstanding higher temperatures, have poorer thermal conductivity. This coupled with increased heat flux means that fin efficiency might be so low as to make extended surface ineffective so that it would be necessary to spread the primary surface. But it should be noted that a rod has a low surface to mass ratio and therefore gives high reactivity; thus to change to some other design may call for the use of enriched fuel.

The effect of raising fuel surface temperature can be gathered from Fig. 5, which plots channel heat rate, q; the average rating of the uranium, m_c, in the most highly rated channel; and channel gas outlet temperature, T_2, against maximum surface temperature of the fuel. Fig. 6 shows the variation of overall efficiency with bulk gas outlet temperature T.

Data from Figs. 5 and 6 have been used to compile Table III, which compares an extrapolated Calder design, having a reacting core 40 ft. in diameter with a plant of the same size core but having a maximum fuel-element surface temperature of 600 deg. C. The increase in output and rating would substantially reduce the capital cost per kW of the plant, but as explained above the uranium would probably require enrichment, which would increase the fuel cost. In this respect the possibility of re-cycling plutonium is relevant; this is discussed later.

The heat rates from the reactors in cases B (i) and (ii) (Table III) are rather large from a single unit and in a specific design it might be beneficial to decrease the core diameter, raise the gas pressure of the system and use larger temperature differences in the heat exchangers. This would reduce the size and cost of the external carbon dioxide circuit, including the heat exchangers, and produce a more balanced design, which would be reflected in a favourable cost per kW for the plant, even if the net output were reduced.

The development of gas-cooled reactors has been focused in the United Kingdom so far on the base-load application. The substantial increase in fuel rating, m, obtained by high-temperature operation increases the economic feasibility of plants of lower power output and for lower load factor, using slightly enriched fuel. But with the introduction of higher temperatures such problems as compatibility of materials assume new importance.

FUEL RE-CYCLING

In a thermal reactor fuelled with uranium, uranium 235 undergoes fission and some of the uranium 238 is converted by neutron capture into plutonium 239 which is fissile to thermal neutrons. By neutron capture, higher isotopes of plutonium are also formed and constitute an important fraction of the plutonium. On a " once through " system in which the charge is irradiated up to, say, 3,000 MWD per tonne, a small proportion only of the plutonium is burnt and the discharged fuel elements contain plutonium, depleted uranium and fission products. In chemical separation plants, similar to the full-scale plants which the U.K.A.E.A. have now been operating for some years, the constituent parts can be separated. The possibility therefore arises of returning the plutonium and part of the depleted uranium to the fuel-element fabrication factory, there to be reconstituted with new feed uranium into fuel elements for charging into the reactor. Fig. 7 illustrates this fuel cycle.

If the plutonium is re-cycled, eventually an equilibrium condition is reached in which the rate of burning plutonium is balanced by the rate of production of fresh plutonium. This is possible in a reactor with a conversion factor of less than unity, if the fissile material, short of the amount required for the reactor to operate, is made up from uranium 235 in new uranium fed into the system. The analysis of such a system is complicated by the fact that as the plutonium is taken to longer irradiations the higher isotopes influence to an increasing degree the performance of the reactor. By successive neutron capture plutonium 239 can become plutonium 241, plutonium 242 and plutonium 243. Plutonium 243 is radioactive with a short half-life (5 hours) and effectively decays almost immediately on formation to americium 243, which would be removed in chemical processing after irradiation. Plutonium 240, 241 and 242 build-up during the approach to the equilibrium system, when the rate of their formation is equal to their rate of destruction by natural decay or neutron capture. Plutonium 240 and 242 are not fissile isotopes, but plutonium 241 is fissile and produces neutrons during fission. The effect of the higher isotopes of plutonium can be seen from Table IV; the values are typical of a reactor of the type shown in Case B of Table III. The mean moderator is assumed to be 700 deg. K. The table shows the number of plutonium atoms required to replace one uranium 235 atom without altering the reactivity. The adverse effect of plutonium 242 in the system is clearly demonstrated by these figures.

It may be shown that potentially the important advantages of fuel re-cycling are (1) it could

TABLE II.—Possible Uranium Cladding Materials

—	Aluminium	Magnesium	Beryllium	Niobium	Zirconium	Stainless steel (18/8/1)
Neutron cross-section, cm.$^{-1}$	0·0118	0·0023	0·00011	0·061	0·0076	0·227
Melting point, deg. C.	660	650	1,284	2,415	1,850	1,500
Thermal conductivity, CHU./h. ft. deg. C. ..	130	90	70	36·4	14·4	9·2
Density at 20 deg. C.	2·7	1·74	1·85	8·57	6·5	7·9

TABLE III.—*Comparison of Extrapolated Calder Design (case A) and Plant with Maximum Fuel-Element surface temperature of 600 deg. C. (case B)*

—	Heat output (MW)	Efficiency (per cent.)	Average uranium fuel rating (MW per tonne)	Electrical output (MW)
Case A: Larger Calder design	400	25	2	100
Case B: High-temp. reactor				
(i) Flattened	1,400	31	5·8	433
(ii) Unflattened	1,100	31	4·5	340

TABLE IV.—*Number of Plutonium Atoms Required to Replace One Uranium 235 Atom Without Altering the Reactivity*

—	Number of plutonium atoms
For pure plutonium 239 fuel	0·44
For 3,000 MWD per tonne plutonium from a natural uranium reactor	0·75
For equilibrium plutonium	2·38
For equilibrium plutonium without plutonium 242	0·99

reduce the natural uranium requirement to meet a given power demand by a significant factor; and (2) under certain conditions, applicable to gas-cooled graphite-moderated reactors, designs requiring initially a charge of slightly enriched uranium, can be subsequently fed with natural uranium once equilibrium conditions are reached. It should also be noted that an alternative procedure, as previously stated, would be to achieve higher values of plutonium burn-up where it is formed within the fuel element.

COOLANTS AND CERAMIC FUELS

For reactors so far discussed it has been assumed that the coolant gas is carbon dioxide. Investigations carried out have shown that, in addition, the following gases might be considered for cooling power reactors: hydrogen, helium and nitrogen. Coolants must be compared on a number of criteria—safety, cost, availability, purity, thermal and irradiation stability, chemical compatibility, neutron absorbing properties, the degree to which they become radioactive—all in addition to their heat-transfer properties. In comparing the heat-transfer properties of gases, reference must be made to the type of heat-transfer surface. Two cases have been discussed: (1) where reliance is placed on primary heat transfer surface, and (2) where most of the heat is transferred from extended surfaces. A criterion ($M^2 c_p^3$ where M is molecular weight and c_p the specific heat at constant pressure) has been derived, assuming Reynolds' analogy to apply, for comparing gases used to remove the same amounts of heat from channels of the same length and area under the same temperature and pressure conditions. The ratio of heat removed to pumping power is proportional to $M^2 c_p^3$. Values at 300 deg. C. (572 deg. F.) for the four gases under consideration are shown in Table V.

TABLE V.—*Values of Heat-transfer Criterion $M^2 c_p^3$*

Gas	$M^2 c_p^3$
Nitrogen (or air)	13·0
Helium	30·6
Carbon dioxide	31·4
Hydrogen	167·0

M = molecular weight; c_p = specific heat.

The ratio of pumping power to heat output for a given gas is proportional to the square of the heat output, so that by substituting, for example, hydrogen for carbon dioxide, an increase in heat output by a factor of $\sqrt{167/30{\cdot}65}$, that is of 2·33, could apparently be obtained. However, with unchanged inlet and maximum fuel-element temperatures a drop in gas outlet temperature would occur. It has also been pointed out that the criterion is not completely satisfactory, because the heat-transfer area is a variable dependent on the gas properties, and unacceptable area might be needed to obtain a given performance. The same criterion applies also to transverse fins of the type used in Calder Works, for which Reynolds' analogy does not apply, but for which a fin-efficiency correlation can be made. Similar criteria could no doubt be developed for other types of extended surface. If a more suitable gas is substituted for the original one, and an attempt made to restore the ratio of pumping power to heat output, the outlet temperature from the reactor can be expected to fall seriously in all cases of extended surface, owing to the reduced efficiency of the extended surface.

The only satisfactory way of comparing the performance of different gases is to evaluate for a specific design. In general, when this is done the differences are not so marked as expressions like ($M^2 c_p^3$) suggest. Carbon dioxide was the gas chosen for the Calder Hall reactors because is was the best compromise between all the requirements. As the temperature of reactor systems is raised, new conditions will be created and helium or nitrogen may supplant carbon dioxide as, comparatively, they are inert gases. Hydrogen is inert at ordinary temperatures but is chemically active at elevated temperature, and further is a highly inflammable gas. Considerable research work would have to be carried out before its feasibility was established for cooling nuclear power reactors; however, its superior heat-transfer properties and favourable nuclear properties are a considerable incentive.

The use of higher temperatures raises special problems concerning fuels and the use of ceramic fuels (compounds of uranium, plutonium or thorium with oxygen or carbon) becomes an important possibility. Compared with the metals, they have much higher melting points, are brittle and soften only at comparatively high temperatures. In general their thermal conductivity is lower, though not in the case of uranium carbides, which have similar values to uranium metal. They have special value in certain possible reactors in which all metal is excluded from the core and the fuel dispersed in the graphite moderator. This and the properties of various ceramics will be discussed further in subsequent articles devoted to specific reactor systems.

REFERENCES

[1] "Nuclear Power in the U.K. and Abroad," by Sir Edwin Plowden.

[2] "Development after 1960," by Sir John Cockcroft. (Both 1 and 2 delivered at a meeting of the International Bank for Reconstruction and Development, Washington, September 27.)

[3] "The Place of the Calder Hall Type of Reactor in Nuclear Power Generation," by Sir Christopher Hinton.

[4] "Development of Gas-Cooled Reactors for Power Production," by Mr. R. V. Moore. (Both 3 and 4 delivered at the "Symposium on Calder Works Nuclear Power Plant," held by the British Nuclear Energy Conference on November 22 and 23.)

BASIC POWER UNITS

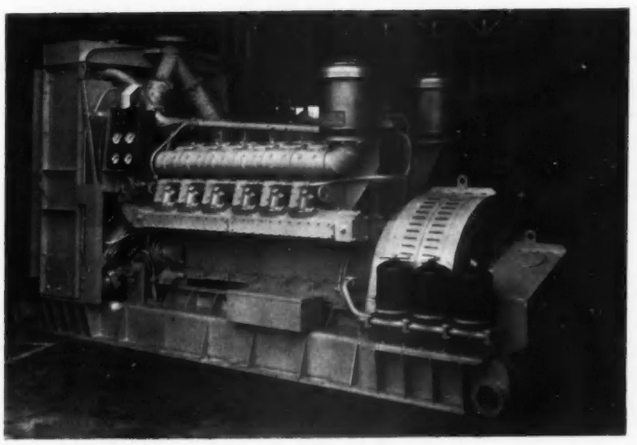
PACKAGED DIESEL ENGINES FOR OIL FIELDS

In the latest versions of the packaged power units made by Davey Paxman and Company, Limited, Colchester, the equipment has been reduced to essentials. This has been done as a result of experience with oil-field operations, where in most cases a basic unit is required to which any needed instrumentation can be fitted, and which does not carry any unwanted items that add to the initial cost. The engines used in these "Drilpak" sets are from the RPH and YHX ranges giving a choice of power at the output shaft from 128 to 800 h.p. at 1,200 r.p.m. The 12 RPH model is shown in the illustration; this has an engine output of 480 h.p. at 1,200 r.p.m. and a corresponding shaft output of 400 h.p. when losses due to auxiliaries and coupling slip have been allowed for.

The sledge on which the engines are mounted is made from rolled steel plate and incorporates all the longitudinal pipe work required. This enables the engine to be removed from its bed very simply. Shield plates below guard the pipes from damage when the sledge is being pulled along over rough ground. All service pipes for air and water, and electric cables for remote control are brought out to a common board at one end. Starting is by a compressed-air motor operating from either a 250 or 100 lb. per sq. in. supply. At one end is mounted what might be described as a cooling "pack," combining both the cooling-water radiator and the heat exchanger for cooling the lubricating oil. Where closed-circuit water cooling is required, as in marine installations, the radiators can be replaced by heat exchangers. Air filters are provided on the engine intakes and on the crankcase breather to prevent the ingress of sand or dust.

The engine drive can be arranged with either a fluid coupling or a torque converter as desired. For the latter requirement a series of matched convertors has been developed by Brockhouse Engineering (Southport) Limited, Crossens, Southport, Lancashire, although other designs can be used. A Pegson pump, which can handle water containing much suspended matter, provides cooling for the fluid coupling. When supplied with set, the fuel tank is mounted directly above the coupling. An emergency stop, operated by a cord which can be taken to any part of the drilling rig, overrides the governor and acts directly on the fuel bar.

The basic set is constructed as shown, without a canopy or doors. The drillings for these are all present however, and so can be added



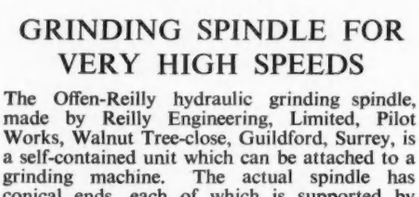
The Drilpak set is a basic unit reduced to essentials. The one illustrated drives through a fluid coupling giving a shaft output of 400 h.p. at 1,200 r.p.m.

at any time. Similarly, as much instrumentation as desired can be added, together with such items as remote air control, alarm signals for overheating and the like. Although the RPH and YHX engines normally run on gas-oil, they can also run on kerosine, and another series, the YHG, is available for operation on natural gas. The 6, 12 and 16 cylinder engines in this range develop 200, 400 and 533 s.h.p. respectively. Other Diesel engines with powers up to 2,000 b.h.p. are available in similar sets. Alternatively, smaller sets can be compounded to give increased total power as, for example, three 6 RPH sets to give 1,000 s.h.p. These can be mounted on a trailer of the same width—13 ft. 6 in.—as developed by General Motors, and will leave ample space for the compounding gear.

★ ★ ★

GRINDING SPINDLE FOR VERY HIGH SPEEDS

The Offen-Reilly hydraulic grinding spindle, made by Reilly Engineering, Limited, Pilot Works, Walnut Tree-close, Guildford, Surrey, is a self-contained unit which can be attached to a grinding machine. The actual spindle has conical ends, each of which is supported by a combined journal and thrust bearing, formed with pressure pockets so that there is no metal-to-metal contact when hydraulic fluid is introduced into the bearing. Rotation of the spindle is by hydraulic jet, there being two jets, diametrically opposed and impinging on a turbine wheel integral with the spindle. The hydraulic drive eliminates belt pull and vibration, and, together with the fluid bearing, gives great accuracy and a fine surface finish.



Hydraulic drive and a hydraulic bearing are features of the Offen-Reilly grinding spindle.

The spindle is being made in several sizes and speed ranges, a typical example being the Type 80 spindle, which is illustrated herewith. It has a spindle nose 0·371 in. in diameter, and will take a grinding wheel of ⅜ in. maximum diameter. The speed range, which is infinitely variable, is from 60,000 to 80,000 r.p.m.

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DIESEL ENGINE FACTORY

It has recently been announced that the Cummins Engine Company Incorporated, Columbus, Indiana, U.S.A., are to establish a plant for the manufacture of Diesel engines at Shotts, in Lanarkshire. Production will be in the hands of the Cummins Engine Company, Limited, a wholly-owned subsidiary of the American firm.

The company are leasing a building of 150,000 sq. ft. from Scottish Industrial Estates Limited, and will ultimately give employment to about 800. At least 75 per cent. of the output will be for export, particularly to countries having difficulty in trading directly with the U.S.A.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Railway Electrification," by R. W. V. Morton. West London Branch. 134 King-street, Hammersmith, W.6. Tues., Dec. 4, 7.30 p.m.
"Control of Oil Burners and Building Heating," by S. O. Grant. North London Branch. Queen's Head, 677 Green Lanes, Harringay, N.4. Wed., Dec. 5, 7.45 p.m.
CROYDON
"Motor Maintenance," by P. H. Usher. South London Branch. Half Moon Hotel, Broad Green, Croydon. Thurs., Dec. 6, 8 p.m.
GLASGOW
"Lighting of Small Factories," by J. S. McCulloch. Glasgow Branch. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Dec. 6, 8 p.m.
ILFORD
"Reclamation by Metal Spray," by B. H. Devis. North East London Branch. Angel Hotel, Ilford. Mon., Dec. 3, 7.30 p.m.
LIVERPOOL
"Modern Short-Circuiting Testing Technique," by J. G. P. Anderson. Liverpool Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Fri., Dec. 7, 7.30 p.m.
READING
"Industrial Uses of Isotopes," by E. W. Jones. Oxford, Reading and Districts Branch. The University, London-road, Reading. Tues., Dec. 4, 7.15 p.m.
SHEFFIELD
"Mineral Insulated Cables for Wiring and Warming," by R. J. Cotton. Sheffield Branch. Royal Victoria Station Hotel, Sheffield. Mon., Dec. 3, 7.30 p.m.

British Institute of Management

GLASGOW
"Can Modern Techniques of Office Management Help Sales?" by A. Mackenzie Parkinson and Harold B. Pearson. Joint meeting with the Glasgow and West of Scotland Management Association. St. Enoch Hotel, Glasgow. Fri., Dec. 14, 7.15 p.m.

British Institution of Radio Engineers

CARDIFF
"Voltage Stabilisation," by Dr. F. A. Benson. South Wales Section. College of Technology and Commerce, Cathays Park, Cardiff. Wed., Dec. 5, 6.30 p.m.
MANCHESTER
"Electronic Automation Applied to the Wind Tunnel," by D. S. Wilde. North Western Section. College of Technology, Sackville-street, Manchester, 1. Thurs., Dec. 6, 6.30 p.m.

Building Centre

LONDON
Films on "Prestressed Concrete" exhibited by Concrete Ltd. Wed., Dec. 5, 12.45 p.m.

Chemical Society

ABERDEEN
"Polarographic Studies in Physical and Analytical Chemistry," by Dr. W. Furness. Aberdeen Branch. Marischal College, Aberdeen. Fri., Dec. 7, 7.30 p.m.
BRISTOL
"Corrosion Fatigue," by T. D. Weaver; and "Stress Corrosion," by Dr. K. R. Wilson. Bristol Branch. Chemistry Department, The University, Bristol, 8. Thurs., Dec. 6, 6 p.m.
EDINBURGH
"Application of Disintegrators and Conveyor Heat Exchangers in the Chemical and Food Industries," by T. S. Ling. Edinburgh Branch. North British Station Hotel, Edinburgh. Thurs., Dec. 6, 7.30 p.m.
MANCHESTER
"New Aspects of the Sequestration of Metals," by Dr. R. L. Smith. Manchester Branch. Chemistry Lecture Theatre, The University, Manchester. Fri., Dec. 7, 6.30 p.m.

Illuminating Engineering Society

CARDIFF
"Lighting as a Basis for Design," by D. Phillips. Cardiff Centre. Offices of the South Wales Electricity Board, The Hayes, Cardiff. Thurs., Dec. 6, 7 p.m.
EDINBURGH
"Lighting of Small Factories," by J. S. McCulloch. Edinburgh Centre. Y.M.C.A., 14 South St. Andrew-street, Edinburgh. Wed., Dec. 5, 6.15 p.m.
HULL
"An Architect's Approach to Lighting Design," by G. Grenfell Baines. Leeds Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Mon., Dec. 3, 7 p.m.
NOTTINGHAM
"Lighting at London Airport," by J. G. Holmes. Nottingham Centre. Electricity Service Centre, Smithy-row, Nottingham. Thurs., Dec. 6, 6 p.m.*

Incorporated Plant Engineers

LONDON
"Refrigeration and the Heat Pump," by Sir Oliver Lyle. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Dec. 4, 7 p.m.*
NOTTINGHAM
Film Evening. East Midlands Branch. County Hotel, Theatre-square, Nottingham. Wed., Dec. 5, 7 p.m.
PETERBOROUGH
Discussion on "The Control of Loads on the Grid." Peterborough Branch. White Lion Hotel, Church-street, Peterborough. Fri., Dec. 7, 7.30 p.m.
SOUTHAMPTON
"Applications of Plastics in Industry," by C. L. Child. Southern Branch. Polygon Hotel, Southampton. Wed., Dec. 5, 7.30 p.m.

Institute of British Foundrymen

BRADFORD
"Use of Exothermic Compounds," by G. N. Cherry. West Riding of Yorkshire Branch. Technical College, Bradford. Sat., Dec. 8, 6.30 p.m.
CARDIFF
"CO_2 Process," by G. E. Parramore. Wales and Monmouth Branch. South Wales Institute of Engineers, Park-place, Cardiff. Sat., Dec. 8, 6 p.m.
GLASGOW
Discussion on "Foundry Problems." Scottish Branch. Royal Technical College, George-street, Glasgow. Sat., Dec. 8, 3 p.m.
HANLEY
"Mechanised Foundries," by H. A. Fox. Stoke Section. Stipendiary Court Room, Hanley. Thurs., Dec. 6, 7.30 p.m.
SHEFFIELD
"Some Aspects of Research and Their Application to the Foundry Industry," by Dr. A. H. Sully. College of Commerce and Technology, Pond-street, Sheffield. Mon., Dec. 3, 7 p.m.

Institute of Marine Engineers

SUNDERLAND
"The Modern Marine Steam Turbine," by J. H. Gooch. Junior Lecture. North East Coast Section. Technical College, Sunderland. Thurs., Dec. 6, 4 p.m.

Institute of Metals

LONDON
"The Founding of Magnesium," by Dr. E. F. Emley. London Local Section. Thurs., Dec. 6, 6.30 p.m.*
OXFORD
Film Evening. Oxford Local Section. Cadena Café, Cornmarket-street, Oxford. Tues., Dec. 4, 7 p.m.

Institute of Petroleum

LONDON
"Hydraulics of Drilling Mud Flow," by P. W. Cooke. Wed., Dec. 5, 5.30 p.m.*

Institute of Refrigeration

LONDON
"Cooling Problems in High-Speed Military Aircraft," by Miss B. Shilling. Junior Institution of Engineers, Pepys House, 14 Rochester-row, S.W.1. Thurs., Dec. 4, 5.30 p.m.*

Institute of Road Transport Engineers

BRISTOL
"Maintaining the Local Light-Weight Vehicle," by W. F. Turton. Western Centre. Royal Hotel, Bristol. Thurs., Dec. 6, 7.30 p.m.
EDINBURGH
"Road and Rig Testing of Prototype Road-Transport Vehicles and Their Components," by J. H. Alden. Scottish Centre. North British Hotel, Edinburgh. Mon., Dec. 3, 7 p.m.
NOTTINGHAM
"Exhaust Brake Design and Operation," by A. G. Slee and W. K. Cox. East Midlands Centre. Mechanics' Institute, Nottingham. Wed., Dec. 5, 7.30 p.m.

Institution of Chemical Engineers

LONDON
"High-Intensity Combustion in Chemical Engineering," by R. P. Fraser. Geological Society, Burlington House, Piccadilly, W.1. Tues., Dec. 4, 5.30 p.m.
CHESTER
"Centrifugation as a Unit Operation," by F. A. Groves. North Western Branch. Birkenhead Technical College, Chester. Tues., Dec. 4, 7.15 p.m.

Institution of Civil Engineers

LONDON
"Design and Construction of a Laboratory for Research in Under ater Ballistics," by C. L. Champion, R. J. R. Hancock and W. Woolfson. Works Division. Tues., Dec. 4, 5.30 p.m.*
GLASGOW
"The Mechanisation of Construction, with Particular Reference to Heavy Excavation Techniques," by James Robertson.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institute of Management, Management House, 8 Hill-street, London, W.1. (GROsvenor 6000.)
British Iastitution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Refrigeration, New Bridge Street House, New Bridge-street, London, E.C.4. (CENtral 4694.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool 2. (Central 3717.)
Manchester Association of Engineers, 18 Booth-street, Manchester 2. (Central 1717.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Société des Ingénieurs Civils de France (British Section), 82 Victoria-street, London, S.W.1. (VICtoria 6838.)
Society of Engineers, 17 Victoria-street, London, S.W.1. (ABBey 7244.)

Glasgow and West of Scotland Association. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Fri., Dec. 7, 7.15 p.m.

MANCHESTER
"Construction of Middleton Connecting Sewer in North Manchester," by E. H. Collier. North Western Association. Engineers' Club, Albert-square, Manchester. Thurs., Dec. 6, 6.30 p.m.

Institution of Electrical Engineers

LONDON
"Electronics and Automation: The Use of Nucleonic Devices," by Dr. Denis Taylor. Joint Meeting of Radio and Measurement Sections. Mon., Dec. 3, 5.30 p.m.*
"Absolute Calibration of Voltage Transformers," by W. K. Clothier and L. Medina, read by G. W. Bowdler. Measurement and Control Section. Tues., Dec. 4, 5.30 p.m.*
"Air Navigation," by P. L. M. Rockwell. London Graduate and Student Section. Wed., Dec. 5, 6.30 p.m.*
"Measurement of Earthloop Resistance," by Dr. G. F. Tagg. Thurs., Dec. 6, 5.30 p.m.*

BIRMINGHAM
"Crystal Palace Television Transmitting Station," by F. C. McLean, A. N. Thomas and R. A. Rowden. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Dec. 3, 6 p.m.*

CARLISLE
"Age and the Incidence of Fires in Electrical Installations," by L. Gosland. North Eastern Centre. Carlisle Technical College, Carlisle. Fri., Dec. 7, 7 p.m.

LEEDS
"Electronics and Automation: Some Industrial Applications," by Dr. H. A. Thomas. North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Dec. 4, 6.30 p.m.

Institution of Engineering Designers

LONDON
Discussion on "What is an Engineering Designer," opened by S. F. Page and P. J. Booker. Thurs., Dec. 6, 6.45 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Some Observations on Local Vibrations," by A. J. Johnson and P. W. Ayling. Tues., Dec. 4, 6.30 p.m.

Institution of Heating and Ventilating Engineers

LONDON
"Storage of Oil Fuel," by T. Chippindale. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Dec. 5, 6 p.m.*

NOTTINGHAM
"An Investigation of the Possibilities of Partial Prefabrication of Heating Plant," by J. L. Burgin and N. Jackson. East Midland Branch. College of Arts and Crafts, Waverley-street, Nottingham. Wed., Dec. 5, 6.45 p.m.

Institution of Highway Engineers

LONDON
"Reduction of Costs and Increase of Speed in Road Construction," by Colonel R. Berridge and J. H. W. Turner. 11 Upper Belgrave-street, S.W.1. Fri., Dec. 7, 5.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "The Sphere and Duties of the Industrial Education Officer." Education Group. Thurs., Dec. 6, 6.45 p.m.*
"Self-Excited Vibration of Axial-Flow Compressor Blades," by A. D. S. Carter and D. A. Kilpatrick. Fri., Dec. 7, 6 p.m.*

BARROW-IN-FURNESS
"Fretting Corrosion," by R. B. Waterhouse. North Western Branch. Central College of Further Education, Barrow-in-Furness. Fri., Dec. 7, 7.30 p.m.

HITCHIN
"Fatigue of Metals," by Professor J. A. Pope. Eastern Branch. Sun Hotel, Hitchin. Tues., Dec. 4, 7.30 p.m.

LOUGHBOROUGH
"Nuclear Reactor Fundamentals," by B. L. Goodlet. East Midland Branch. College of Technology, Loughborough. Wed., Dec. 5, 7 p.m.

MANCHESTER
"Problems of High-Speed Flight," by R. F. Creasy. North Western Branch. Engineers' Club, Albert-square, Manchester. Thurs., Dec. 6, 6.45 p.m.

NEWCASTLE-UPON-TYNE
"A Standard Gas Turbine to Burn a Variety of Fuels," by G. B. R. Feilden, D. R. Thorn and M. S. Kemper. North Eastern Branch. Neville Hall, Newcastle-upon-Tyne. Mon., Dec. 3, 6 p.m.

PORTSMOUTH
"Power Station Auxiliary Plant," by Geoffrey F. Kennedy and F. J. Hutchinson. Southern Branch. College of Technology, Portsmouth. Wed., Dec. 5, 6.30 p.m.*

Institution of Production Engineers

BRISTOL
"Problems and Prospects of British Aviation," by P. G. Masefield. Western Section. University Engineering Laboratories, University-walk, Bristol, 8. Wed., Dec. 5, 7.15 p.m.

CHELMSFORD
"Future Trends in Technical Education," by F. Bray. South Essex Section. Mid-Essex Technical College, Chelmsford. Wed., Dec. 5, 7.30 p.m.

CROYDON
"Electronics as an Aid to Production, with Special Reference to the Aircraft Industry," by T. A. Waite. London Section. Offices of Powers-Samas Accounting Machines Ltd., Aurelia-road, Croydon. Thurs., Dec. 6, 7 p.m.

LIVERPOOL
"Practical Application of Production Engineering Research," by Dr. D. F. Galloway. Liverpool Section. Central Libraries, William Brown-street, Liverpool. Wed., Dec. 5, 7.30 p.m.

NOTTINGHAM
"Factory Fundamentals for a Small Factory," by Hal Gutteridge. Nottingham Section. Victoria Station Hotel, Milton-street, Nottingham. Wed., Dec. 5, 7 p.m.

PETERBOROUGH
"Nuclear Power and Its Effect on the Production Engineer," by I. Munro. Peterborough Section. White Lion Hotel, Church-street, Peterborough. Thurs., Dec. 6, 7.30 p.m.

Institution of Structural Engineers

BELFAST
"Tubular Steel Structures," by R. G. Taylor. Northern Ireland Branch. College of Technology, Belfast. Tues., Dec. 4, 6.45 p.m.

BRISTOL
"Structures Involving Unusual Design Problems," by C. E. Saunders. Western Counties Branch. The University, Bristol. Fri., Dec. 7, 6 p.m.

LEEDS
"Use of Gunite as a Structural Material," by T. Whitley Moran. Yorkshire Branch. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Wed., Dec. 5, 6.30 p.m.

PLYMOUTH
"Plymouth Breakwater Review," by T. W. Riley. South Western Counties Branch. Duke of Cornwall Hotel, Plymouth. Fri., Dec. 7, 6 p.m.

Junior Institution of Engineers

LONDON
Film "Refloating of Empress of Canada," introduced by Lieut.-Commander L. Hackman. Fri., Dec. 7, 7 p.m.*

BIRMINGHAM
"Work Study," by V. N. Picken. Midland Section. James Watt Memorial Institute, Birmingham. Wed., Dec. 5, 7 p.m.

Liverpool Engineering Society

LIVERPOOL
"Some Impressions of a Visit to Russia," by A. R. Cooper. Royal Institution, Colquitt-street, Liverpool. Mon., Dec. 3, 6.30 p.m.

Manchester Association of Engineers

MANCHESTER
"Mechanical Handling Equipment," by F. T. Dean. Engineers' Club, Albert-square, Manchester. Fri., Dec. 7, 6.45 p.m.

Royal Society of Arts

LONDON
"Engineering Electronics," by Dr. L. E. C. Hughes. Second of three Cantor Lectures. Mon., Dec. 3, 6 p.m.

Société des Ingénieurs Civils de France (British Section)

LONDON
"French Dual-Purpose Scheme: The Durance Project and the Serre-Ponçon Dam," by R. Giguet. Institution of Civil Engineers, Great George-street, S.W.1. Thurs., Dec. 6, 5.30 p.m.*

Society of Engineers

LONDON
"The Submarine: Past, Present and Future," by Sir Charles S. Lillicrap. Geological Society, Burlington House, Piccadilly, W.1. Mon., Dec. 3, 5.30 p.m.*

ATOMIC REVIEW

High Priority

Revision of United Kingdom atomic power programme may be announced this year—Fission product and heavy element concentrations in homogeneous reactors—Effect on boiling water of reactor flux—Induced activity in sodium—Increasing thermal efficiency of reactor installations (a) *by using pentane as working fluid and* (b) *by employing both nuclear and conventional fuels in the same plant—Properties of plutonium—Space and process heating by atomic energy—Vacuum tank for CERN accelerator—CERN symposium proceedings published—Wall chart of Calder Hall—Courses and booklet on radiological protection—Commonwealth nuclear development — Nitrogen* 15 *— German atomic monthly—Legal aid.*

Power Programme Revision

To-day's closed conference on advanced reactors at Harwell (Editorial comment, page 673; article, page 694) may be a prelude to considerable changes in the United Kingdom atomic energy programme. It may for example be revealed to representatives of British industry that one of the reactor systems proposed for Stage II offers fewer advantages when compared with the gas-cooled system than was previously supposed; it may also be announced that certain kinds of advanced reactor are to be built at an earlier date than had originally been planned. Stocks of plutonium should by 1963-64 be sufficient to provide enriched fuel for these reactors, given that the technical problems associated with its use have by then been solved. In addition, it is likely that the programme itself will be accelerated and expanded, though whether increased demands can be met depends on the availability of suitable manpower and the necessary materials. Mr. Aubrey Jones, Minister of Fuel and Power, has acknowledged that the White Paper published in February, 1955, is out of date, and he hopes to be able to announce a revision of the programme before the end of the year. This will presumably be in addition to the increased outputs anticipated from the earlier stations, and may mean that the original 12 stations planned to operate by 1965 will be augmented by a further three or more—possibly based on systems using some fuel enrichment.

The inadequacy of coal stocks and current insecurity of oil supplies underlines the importance of enlarging the atomic power programme, even if this means some austerity in other fields. Sir Claude Gibb has suggested that in view of the fuel situation (see page 680) the number of stations planned should not be 12 but 112! Recently, Mr. R. A. Butler has said: "It may well be that some time after 1965 every new power station will be atomic, and it may well be that by 1975 the total output of atomic stations will certainly be more than, and may be double, the total electrical output of all the power stations that serve our needs for electricity to-day." Many of the later stations in this programme will be based on advanced reactor systems, the investigation of which is at present a high-priority commitment of the United Kingdom Atomic Energy Authority. A number of U.K.A.E.A. reactor studies are summarised below.

Homogeneous Reactors

A highly promising advanced reactor is that based on the homogeneous system, in which fuel and moderator—and in effect primary coolant—are intimately mixed as a solution or liquid slurry. The advantages are mainly in terms of heat transfer and simplicity of fuel processing. Sir John Cockcroft has suggested that it may lead to 4 mill power (less than 0·4*d.* per kWh) in 10 or 15 years. Homogeneous systems may use a solution of fissile material in water (aqueous homogeneous) as with the thorium-uranium 233 breeding cycle in which the core comprises a uranyl sulphate solution and the blanket a solution of thorium oxide (thoria); or a slurry of uranium in bismuth (or uranium-thorium-bismuth) as in a liquid-metal fueled reactor.

Some data for homogeneous reactor systems have recently been published. An Atomic Energy Research Establishment document gives fission-product concentrations and poisoning in a homogeneous reactor with continuous chemical processing. Tables and graphs are presented giving the steady-state fission product concentrations and total capture cross-sections in the core of a homogeneous reactor for various rates of chemical processing. The results are as general as possible; otherwise they are detailed for the specific system of a liquid-metal homogeneous reactor based on uranium dissolved in bismuth. Estimates are also given of the rate of production of inert gases in the main circuit. The transient condition when the reactor is first started up is not considered. (W. A. L. Porter. AERE M/R 1889.)

The problem of fission-product formation in reactors with circulating fuel has also been dealt with in mathematical terms. In such reactors the fuel is exposed to intermittent radiation. Formulae are presented which enable the amount of any fission product present after any time of reactor operation to be calculated for various conditions. Means of calculating the quantity of fission-product gases present in the reactor assuming various efficiencies of removal are also given. (C. J. Lock. AERE C/M 278.)

Another document is concerned with the concentrations of the heavy elements in a liquid-metal fueled reactor also with chemical processing. It presents tables and charts giving the concentrations of heavy isotopes in the blanket and core of a homogeneous reactor system with particular reference to a uranium-thorium-bismuth liquid-metal fuelled reactor. The processing rates for transfer of fissile material from the blanket to the core are established for steady-state operation. The build-up of non-fissile uranium and fission products on start-up is also discussed. (W. A. L. Porter. AERE M/R 1950.)

Boiling Water Reactors

Last week we referred to reactor systems in which some boiling occurs in the reactor core. One of the factors to be considered in such systems is the effect on boiling water of reactor flux. The detailed behaviour of any boiling system depends quite strongly on the supply of suitable nucleation sites where small vapour

bubbles may form. The highly localised deposition of the kinetic energy of protons and oxygen ions which have been accelerated by the neutron flux in a reactor could serve as a nucleating agent in some circumstances. It is shown that this could not be expected in water boiling at atmospheric pressure, but that at 600 lb. per sq. in. it is impossible at present to state whether there would be any such effect, or what its significance as far as heat transport is concerned would be. It is also argued that there is little significance for reactor kinetics in the fact that 5 per cent. of the fission energy is carried in long range neutron and γ radiation, thus by-passing some thermal conduction delays. (W. M. Lomer. AERE T/M 136.)

Sodium Coolant

In fast reactors, such as that building at Dounreay, and in other reactors having small highly enriched cores, the heat output per unit volume may be very large. In cases of this kind gas cooling is likely to be inadequate, and a liquid metal, such as sodium may be used. The usefulness and safety of such systems may depend on the extent of the activity induced in the sodium, though use of a heat exchanger within the reactor shield and a secondary coolant may minimise this problem. Induced activity will be limited to the primary coolant passing through the reactor, since neutrons, which are responsible for the induced activity, are only produced within the reactor core. The thermal neutron activation cross-section of sodium has been measured relative to that of gold by comparing the induced activities in sodium carbonate samples irradiated in the thermal column of BEPO with gold foil samples irradiated simultaneously. The induced activity was measured absolutely by β-γ coincidence counting. By taking a value of 98·5 barns for the absorption cross-section of gold for 2,200 m. per sec. neutrons

$$\sigma_{Na}\ (\text{absorption}) = 0{\cdot}536 \pm 0{\cdot}006\ \text{barn.}$$

(S. J. Cocking and J. F. Raffle. AERE HP/R. 1894.)

Pentane as Working Fluid

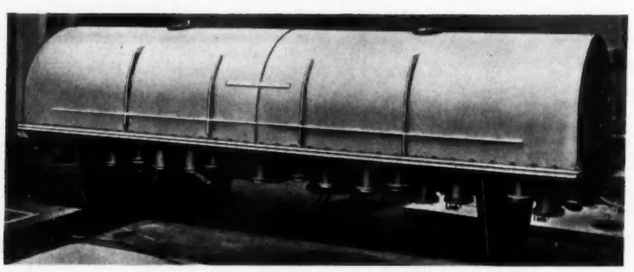
A Hungarian paper reproduced in *Engineers' Digest* (vol. 17, page 281, 1956) discusses the theoretical possibilities of improving the cycle efficiency of nuclear power plants. It gives reasons for maintaining that maximum efficiency cannot be achieved with the classical steam cycles, and suggests other working fluids likely to bring better thermodynamic results. One of these is pentane and a pentane system is described and compared with a steam system. Another way of improving thermal efficiency proposed is to combine nuclear energy with the energy of conventional fuels. A cycle based on such a combination is shown to have an efficiency of 57 per cent. (L. Heller. *Acta Technica*, Academiae Scientarum Hungaricae, vol. 14, page 137, 1956.)

Plutonium

Before plutonium can be satisfactorily used as a reactor fuel, its properties must be established in detail. Recently published studies have covered evaporation tests, ionisation potential and electron emission. Tests have been made on the evaporation of plutonium from crucibles of different materials in order to find the fraction which can be evaporated. The best crucible materials were found to be tungsten or tantalum. Graphite, either alone or coated internally with aluminium oxide (Al_2O_3) or beryllium oxide (BeO) was unsatisfactory. By estimating the rate of effusion from the crucible the vapour pressure of plutonium was found to be 10^{-3} mm. of mercury at 1,450 deg. $\pm$ 50 deg. C. Seven per cent. of plutonium atoms striking a tungsten surface at 2,600 deg. C. were ionised when the incident flux of neutrons was in the region of 10^{15} to 10^{16} atoms per sq. cm. per sec. Under the same conditions a measurement of the saturated electron and ion emission gave a value of $5{\cdot}1 \pm 0{\cdot}5$ electron volts for the ionisation potential of plutonium. Tungsten and tantalum surfaces coated with plutonium gave electron emissions comparable with that from thoriated tungsten. (R. H. V. M. Dawton and K. L. Wilkinson. AERE GP/R 1906.)

Atomic Heating

Interest in novel reactor systems may distract attention from alternative reactor applications; power, plutonium and radioactive isotopes are familiar products of reactors, but their use as sources of space or process heating has not received comparable notice in this country. The Atomic Power Company of Finland are considering the construction of reactors (the first to be ready by 1960) to produce steam for the wood-pulp industry with electricity as a secondary product. Representatives of the company have visited both Britain and the United States with this in view. Six atomic heating plants are also to be built in Sweden. The Scandinavian countries with their large forestry industries are likely to provide a considerable market for reactor installations of this kind. Sweden is also to complete during the period 1960-66 two nuclear power stations; the first, due to begin operating in 1963, is to have a capacity of 100 MW, and the second a capacity of 200 MW. A.B. Atomenergi, the partly state-owned company responsible, have also ordered a research reactor, which is to be supplied by the American A.C.F. Industries and completed by 1958.



One of three vacuum tanks with a total volume of 50,000 litres being made by Metropolitan-Vickers for the CERN 50 MeV proton linear accelerator. They will be continuously evacuated by five mercury diffusion pumps.

Vacuum Tank for Nuclear Research

The illustration on the left hand side of this page shows a vacuum tank which was recently shipped to Geneva for use with the 50 MeV proton linear accelerator being constructed by the Metropolitan-Vickers Electrical Company, Limited, for the European Organisation for Nuclear Research (CERN). Three such tanks are required, with a total volume of some 50,000 litres. They will be continuously evacuated by five mercury diffusion pumps of a type recently developed by Metropolitan-Vickers; refrigerated baffles are used to prevent the migration of mercury vapour into the tanks. Separate "rough" pumping systems will be used to obtain the degree of vacuum necessary before the mercury pumps can come into operation. For shipment, each tank is filled with an inert gas to prevent corrosion during transit and erection.

Notes and Notices

The "Proceedings of the CERN Symposium on High-Energy Accelerators and Pion Physics" (see ENGINEERING, vol. 181, page 542, 1956) have recently been published in two volumes. They are obtainable from CERN—Service d'Information, Case Postale 25, Geneva 15, Switzerland.

A coloured wall chart with key, 2 ft. by 3 ft., showing in simplified part section Britain's first atomic power station at Calder Hall has recently been published by the U.K.A.E.A. The price is 2*s.* and orders should be sent to Room 817, Public Relations Branch, U.K. Atomic Energy Authority, St. Giles-court, St. Giles High-street, London, W.C.2.

The widespread use in industry and elsewhere of radioactive isotopes created a demand for advice on the precautions necessary to ensure the safe handling and disposal of these materials. A series of short courses on radiological protection, each of four days duration, was therefore instituted. It is proposed to hold further courses on the subject—these to last five days—and inquiries should be addressed to the Isotope School, A.E.R.E., Harwell, Didcot, Berkshire. A booklet, in which the course material is assembled, entitled: "A Short Course in Radiological Protection" (AERE HP/L 23: price 13*s.* 3*d.*) has recently been published. Edited by R. J. Sherwood and H. J. Dunster, it includes discussions of the following subjects: elementary nuclear physics and units, energy of various radiations, organisation of a radiation protection service, radiation detection, permissible levels, control of hazard and contamination, health-physics instruments, decontamination and waste disposal.

Other booklets published recently are *The Commonwealth and Nuclear Development*, which is a Central Office of Information Reference Pamphlet (H.M.S.O., price 3*s.* 6*d.*), and *Bibliography on Nitrogen* 15, National Bureau of Standards Circular 575 (U.S. Department of Commerce) published by U.S. Government Printing Office, Washington, D.C., price 15 cents.

A monthly review *Die Atomwirtschaft*, dealing exclusively with "the economic utilisation of atomic energy," is being published by Verlag Handelsblatt G.m.b.H., Düsseldorf, Pressehaus. A double issue, which appeared earlier this year, was devoted to nuclear reactors and included a 15 page table summarising data for some 63 reactor installations throughout the world. The yearly subscription is 10 dols. or 42 D.M. and the price of the double issue 1·40 dols. or 6 D.M.

Postscript

In Canada it is reported that radiation analysis has been used to determine the amount of arsenic in the hair of a man believed to have been murdered. The results—perhaps to the disappointment of the experts concerned—confirmed the original diagnosis of heart attack. The idea of police searching for irradiated criminals with a Geiger counter is somewhat far fetched, but it is encouraging to learn that to the many familiar benefits of radiation techniques the cause of justice has been added. We understand that the pursuit of golf balls may also be aided by such methods, which, if widely adopted, would certainly stimulate the sale of radiation monitors to small boys. Incidentally, we can never find our fountain pen.

* * *

ECONOMICS OF THE REHEAT CYCLE

Gains in Efficiency of 4½ per cent. Achieved

The reasons for the choice of a reheat cycle for the direct reversing steam turbines of the Empress of Britain were given in detail in a paper* presented by Mr. A. W. Davis to the Institute of Marine Engineers on November 13. Reheat-

* "Reheating as a Contribution to the Economy of the Marine Steam Turbine, with Special Reference to the Installation in T.S.S. 'Empress of Britain'," by A. W. Davis, B.Sc., deputy managing director, Fairfield Shipbuilding and Engineering Co. Ltd.

ing presents certain difficulties in the case of reversing turbines driving directly through gearing, difficulties which are avoided by using non-reversing turbines with electric transmission. Unfortunately the latter arrangement involves a certain loss in efficiency which offsets the gain given by the reheating. Reversible-pitch propellers were considered as having a degree of hazard to reliability, and reversible gears have yet to be proved in practice. With a reheat cycle, to be able to reverse the turbines, there would have to be either damper control of the reheat elements or a separately fired boiler. The latter was selected with the proviso that its efficiency should not be less than that of the main boilers.

The steam conditions chosen were 680 lb. per sq. in. gauge at the boiler and 850 deg. F., with reheat to 850 deg. F. from 610 deg. F. The two Pametrada turbines* each develop 15,000 s.h.p. and have high, intermediate and low-pressure stages, the power division being 22, 40 and 38 per cent., respectively. By-pass and isolating valves on the reheat boiler circuit are interlocked, and protect the system both when starting up and for an emergency shut down.

TRIALS

Very careful trials were carried out, and a good heat balance obtained using oil with a calorific value of 18,500 B.Th.U. per lb. and special recording equipment. All-purpose fuel consumption was 0·54 lb. per s.h.p.-hour, and for propulsion only 0·495 lb. per s.h.p.-hr. These compare with 0·62 and 0·57 lb. per s.h.p.-hr. obtained on the Empress of Scotland (completed 1930) and 1·13 and 1·05 lb. per s.h.p.-hr. on the Empress of Canada (1922). Corresponding figures for power/weight ratio are 13·4, 8·5 and 6·3 s.h.p. per ton of machinery. Thus since 1922 the power/weight ratio has been doubled and the fuel consumption halved.

The reheat cycle has given a gain of 4½ per cent, in efficiency compared with a direct cycle plant operating under similar conditions; with adjustments to design this could be increased to 6 per cent. Further gains might be possible by using a higher initial steam pressure.

* For a full description of the machinery, see ENGINEERING, vol. 181, pages 258 and 316, 1956.

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AUTOMATICALLY PROPORTIONED MIXTURES

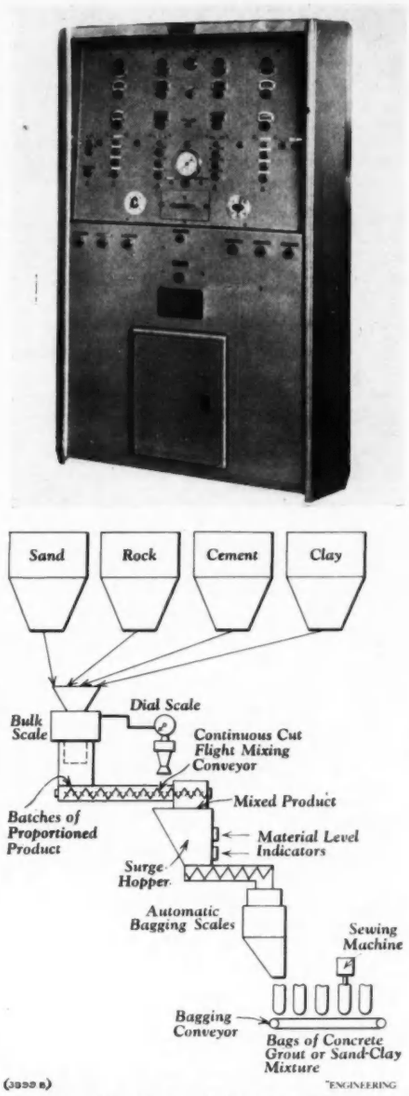
Development in Processing Plant

An American development in automatic processing, applicable to almost any industry in which materials are mixed into batches of fixed or variable formulae, is now being manufactured and marketed by Henry Simon Limited, Cheadle Heath, Stockport, after an extensive research and development programme. The Select-O-Weigh system, as the new technique is known, which was originated by the Richardson Scale Company, Clifton, New Jersey, U.S.A., brings the whole of the feeding, weighing, mixing and discharging cycle under the control of a central panel on which the weights of individual ingredients may be set up by manually-operated dials or by a punched-card programming mechanism.

In a typical installation, such as, for example, the concrete plant illustrated in the accompanying diagram, each ingredient is stored in a supply bin terminated by an electrically-powered discharger. The dischargers feed into the weigh hopper of a dial scale, also equipped with an electrically-operated discharging mechanism.

A device in the dial head sets up an electrical condition analogous to the angular displacement of the pointer. The remote-control panel also contains the means of setting up an electrical equivalent of any desired weight for each ingredient.

When the equipment is started, the first ingredient feeds into the dial scale, the electrical condition of which is continuously compared with the corresponding condition set up on the panel. When the two coincide, feeding of the first ingredient stops and the feeders for the second and subsequent ingredients are automatically energised each in its correct sequence. On completion of the batch, the weigh hopper discharges automatically into a mixer, conveyor or other receptacle, and the Select-O-Weigh system resets itself for the next batch which may be automatically or manually initiated as desired.



An application of the Select-O-Weigh system, in which the feeding, weighing, mixing and discharge cycle is controlled automatically from a central panel, to concrete manufacture.

Automatic tare checks prevent the start of a batch unless the scale is in perfect empty balance. It is customary to provide interlocks and sequencing for conveyors, mixers and other auxiliary equipment; and it is possible to provide several different kinds of remote recording and indication of the performance of the system.

There are few limitations on the number, nature and quantities of the materials handled. Up to a dozen ingredients can be handled by a single scale; multiple scale installations can deal with far more complex formulations.

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Henry Simon Limited are planning a demonstration of the Select-O-Weigh system for management executives at their headquarters. Those interested are invited to get in touch with Mr. C. R. Hicks, Henry Simon Limited, Cheadle Heath, Stockport.

PROFILE CUTTING BY BANDSAW

For Metals, Wood or Plastics

The "Volant" 18 in. throat bandsaw, which has been added to the range of machines made by the Startrite Engineering Company, Limited, Gads Hill, Gillingham, Kent, takes bandsaws ⅛ in. to ½ in. wide, which are suitable for cutting metal, wood or plastics. Scalloped-edge knife blades can be supplied for cutting rubber, cardboard, paper and other materials.

The machine has a work table 20 in. by 19 in. which is arranged to tilt 45 deg. to the right and 5 deg. to the left. A T-slot in the table apron carries a fence attachment with fine screw adjustment. Access to the lower saw guide is gained through a large removable disc-type insert in the table. Drive is taken direct from a motor, mounted in the base of the machine, to a spur gearbox which, with variable pulleys, enables the saw to be run at any one of ten speeds from 56 to 3,200 ft. per minute. The band runs on two steel disc pulleys, which are carried in ball bearings; tensioning and tracking gear are provided at the upper pulley mounting. Ball-bearing rear-thrust rollers, with hardened and ground steel guide blocks, are fitted in the two guide posts which locate the saw at the table.

Standard equipment includes a built-in saw welder, complete with blade shearer, grinder, and annealing controls. There is also a low-voltage spotlight. An integral air pump is provided for operating a swarf-blowing jet, and there is a job-selection dial mounted on the front of the machine head which gives the necessary information for saw and speed selection according to the work in hand.

The "Volant" 18 in. throat bandsaw has a tilting table, and is complete with a range of accessories. There are 10 sawing speeds.

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Last week, owing to an unusual combination of circumstances, errors in the disposition of certain illustrations remained uncorrected before going to press. In an article dealing with the atomic energy facilities of Babcock and Wilcox, Limited, the illustrations to Figs. 9 and 10, on page 667, were interchanged, and the view of equipment in the B.I.C.C. irradiation laboratory on page 670 appeared inverted. We apologise for any inconvenience this may have caused.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list, arranged chronologically, appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of exhibitions and conferences not included below may have appeared in ENGINEERING, *September 28, page 415; or October 26, page 543. Organisers are invited to send to the Editor particulars of coming events as soon as arrangements are made.*

Smithfield Show and Agricultural Machinery Exhibition.—Mon., Dec. 3, to Fri., Dec. 7, at Earl's Court, London, S.W.5. Apply to the exhibition manager, Smithfield Show Joint Committee, 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

***Automation, Education and Training, Conference.**—Tues., Dec. 4, at the Royal Festival Hall, London, S.E.1. Organised by the British Association for Commercial and Industrial Education (BACIE), Management House, 8 Hill-street, London, W.1. Tel. GROsvenor 6231.

Radiology Annual Congress and Exhibition.—Thurs. and Fri., December 6 and 7, at the Caxton Hall, off Victoria-street, London, S.W.1. Organised by the British Institute of Radiology, 32 Welbeck-street, London, W.1.

***Scientific, Technical and Pedagogic Equipment Exhibition.**—Sat., Dec. 15, 1956, to Mon., Jan. 7, 1957, at Valparaiso. Further particulars from the Exhibition Organisers, Santa Maria University, Valparaiso, Chile.

National Boat Show, Third.—Tues., Jan. 1, to Sat., Jan. 12, 1957, in the Empire Hall, Olympia, London, W.14. Organised by the Ship and Boat Builders' National Federation, 205 Regent-street, London, W.1. Tel. REGent 1108.

***Problems of Aircraft Production, Conference.**—Tues. and Wed., Jan. 8 and 9, 1957, at the University of Southampton, Highfield, Southampton. Theme: "New Materials and New Methods." Organised by the Southern Section of the Institution of Production Engineers. Apply to the secretary of the Institution, 10 Chesterfield-street, London, W.1. Tel. GROsvenor 5254.

***Motor Show, 39th International.**—Sat., Jan. 12, to Wed., Jan. 23, 1957, in Brussels. Apply to the commissaire general, Salon de l'Automobile, 22 Rue du Luxemburg, Brussels.

Packaging Exhibition.—Tues., Jan. 22, to Fri., Feb. 1, 1957, at Olympia, London, W.14. Held in collaboration with the Institute of Packaging, and organised, in association with F. W. Bridges and Sons, Ltd., by Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester, 3. Tel. Deansgate 6363.

Western Springs Trade Exhibition.—Sat., Jan. 26, to Sat., Feb. 9, 1957, at Auckland, New Zealand. Apply to Auckland Provincial Public Relations Office, Achilles House, 45 Customs-street East, Auckland C.1, New Zealand.

***Stationery Trade Fair.**—Mon., Feb. 4, to Fri., Feb. 8, 1957, at the Grand and Metropole Hotels, Brighton. Organised by the Stationers' Association of Great Britain and Northern Ireland, 6 Wimpole-street, London, W.1. Tel. LANgham 9256.

Hi Fi Electrical and Radio Show.—Wed., Feb. 6, to Sat., Feb. 9, 1957, in Los Angeles, California. Organised by the Institute of Hi-Fi Manufacturers, 28 Broad-street, New York 4, U.S.A.

***Commercial Vehicle Exhibition, 37th International.**—Thurs., Feb. 7, to Sat., Feb. 16, 1957, at Amsterdam. Offices: R.A.I. Building, Amsterdam Z.1, Holland.

***National Stationery and Book Trades Fair.**—Mon., Feb. 11, to Fri., Feb. 15, 1957, at the Royal Horticultural Society's Old Hall, Vincent-square, and New Hall, Greycoat-street, London, S.W.1. Organised by the National Newsagent (Exhibitions), Ltd., 149 Fleet-street, London, E.C.4. Tel. CITy 2604.

Scottish Dairy Show.—Tues., Feb. 12, to Fri., Feb. 15, 1957, at Kelvin Hall, Glasgow. Organised jointly by the Corporation of Glasgow and the Scottish Agricultural Society. Apply to Mr. Walter Barlow, Kelvin Hall, Glasgow. Tel. Kelvin 1185.

***National Nylon Fair.**—Mon., Feb. 18, to Fri., Feb. 22, 1957, at the Royal Albert Hall, Kensington Gore, London, S.W.7. Apply to Mr. V. G. Sherren, National Trade Press Ltd., Drury House, Russell-street, Drury-lane, London, W.C.2. Tel. TEMple Bar 3422.

Mechanical Engineers' Contribution to Clean Air, Conference on.—Tues., Feb. 19, to Thurs., Feb. 21, 1957, in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476. See ENGINEERING, October 26, 1956, page 519.

Boat Show, International.—Fri., Feb. 22, to Wed., Feb. 27, 1957, in Miami. Offices: 615 S.W. 2nd-avenue, Miami, Florida, U.S.A.

Hardware Trades Fair, Third.—Mon., Feb. 25, to Fri., Mar. 1, 1957, at the Royal Horticultural Society's Old and New Halls, Vincent-square and Greycoat-street, London, S.W.1. Organised by Universal Exhibitions Ltd., 74 Holland Park, London, W.11. Tel. PARk 7723.

Food, Cookery and Catering Trades Exhibition.—Tues., Feb. 26, to Sat., Mar. 9, 1957, at the City Hall, Deansgate, Manchester. Including food-processing machinery. Organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester, 3. Tel. Deansgate 6363.

***Degreasing, All-Day Discussion.**—Wed., Feb. 27, 1957, at The University, Edgbaston, Birmingham. Organised by the Institute of Metals, 17 Belgrave-square, London, S.W.1. Tel. BELgravia 3291.

***Motor Cycle Exhibition.**—Thurs., Feb. 28, to Sun., Mar. 10, 1957, at Amsterdam. Offices: R.A.I. Building, Amsterdam Z.1, Holland.

Metals under High Rates of Strain, Conference on.—In March, 1957, probably in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476.

***Smallwares Trade Fair.**—Mon., Mar. 4, to Fri., Mar. 8, 1957, at the Metropole Hotel, Brighton. Organised by Trade and Technical Exhibitions Ltd., 1 Dorset Buildings, Salisbury-square, London, E.C.4. Tel. FLEet Street 1555.

Copenhagen International Fair.—*Technical Fair*: Tues., Mar. 5, to Wed., Mar. 13, 1957. *Commercial Fair*: Sat., Mar. 23, to Sun., Mar. 31, 1957. In Copenhagen, Denmark. Organised by the International Messe, Vester Farimagsgade 6, Copenhagen V, Denmark. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

Ideal Home Exhibition.—Tues., Mar. 5, to Sat., Mar. 30, 1957, at Olympia, London, W.14. Organised by Associated Newspapers Ltd., 161-163 Queen Victoria-street, London, E.C.4. Tel. FLEet Street 6000.

Atomic Exposition and Nuclear Congress, International.—Mon., Mar. 11 to Fri., Mar. 15, 1957, at the Convention Hall, Philadelphia. Apply to Mr. H. F. Grebe, International Atomic Exposition, 117 South 17th-street, Philadelphia 3, Pa., U.S.A.

***Motor Show, International.**—Thurs., Mar. 14, to Sun., Mar. 24, 1957, in Geneva. Apply to the secretariat general, Motor Show, 1 Place du Lac, Geneva, Switzerland.

Kansas City, International Trade Fair.—Sun., Mar. 17, to Sun., Mar. 24, 1957, at Kansas City. Apply to Mr. L. L. Bratschie, Heart of America International Trade Fair, Inc., 3230 Broadway, Kansas City 11, Missouri, U.S.A.

Photographic Exposition, International.—Fri., Mar. 22, to Sun., Mar. 31, 1957, at the National Guard Armory, Washington. Apply to Mr. R. J. Wilkinson, International Photographic Exposition, 104 East Michigan-avenue, Jackson, Michigan, U.S.A.

Physical Society's Exhibition of Scientific Instruments and Apparatus.—Mon., Mar. 25, to Thurs., Mar. 28, 1957, in the Royal Horticultural Society's Old and New Halls, Vincent-square and Greycoat-street, London, S.W.1. Organised by the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

Western Metal Congress and Exhibition.—Mon., Mar. 25, to Fri., Mar. 29, 1957, in the Pan Pacific Auditorium, Los Angeles, California. Organised by the American Society for Metals, 7301 Euclid-avenue, Cleveland 3, Ohio, U.S.A.

***Industrial Textiles Fair, Second National.**—Mon., April 1, to Fri., April 5, 1957, at the Royal Albert Hall, Kensington Gore, London, S.W.7. Apply to Mr. V. G. Sherren, National Trade Press Ltd., Drury House, Russell-street, Drury-lane, London, W.C.2. Tel. TEMple Bar 3422.

Radio Component Show, 14th.—Tues., April 9, to Thurs., April 11, 1957, at Grosvenor House, Park-lane, London, W.1. Pre-view for overseas and special guests on Mon., April 8. Annual private exhibition organised by the Radio and Electronic Component Manufacturers' Federation, 21 Tothill-street, London, S.W.1. Tel. ABBey 4226. Applications for admission must be made in advance.

Chemical Engineering Education Symposium.—Tues., April 9, to Thurs., April 11, 1957, at The University, Birmingham. Organised by the Midlands Branch, Institution of Chemical Engineers. Apply to the secretary of the Institution, 16 Belgrave-square, London, S.W.1. Tel. BELgravia 3647.

Electrical Engineers' Exhibition, Sixth.—Tues., April 9, to Sat., April 13, 1957, at Earl's Court, London, S.W.5. Sponsored by the Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. Apply to Mr. P. A. Thorogood, Electrical Engineers (A.S.E.E.) Exhibition, Ltd., 6 Museum House, 25 Museum-street, London, W.C.1. Tel. MUSeum 3450.

***British Photo Fair.**—Thurs., April 11, to Wed., April 17, 1957, at Olympia, London, W.14. Apply to British Exhibitions Ltd., 52 Grafton-way, London, W.1. Tel. EUSton 7930.

***London Audio Fair.**—Fri., April 12, to Mon., April 15, 1957, at the Waldorf Hotel, Aldwych, London, W.C.2. Further information from Mr. L. H. Brooks, 17 Stratton-street, London, W.1. Tel. GROsvenor 1926.

United States World Trade Fair.—Sun., April 14, to Sat., April 27, 1957, at the New York Coliseum, New York. *Managers:* The Charles Snitow Organisation, Inc., 331 Madison-avenue, New York, 17. Information may be obtained from the British Commonwealth Chamber of Commerce in the United States, 677 Fifth-avenue, New York, 22; and from the Fair's British and Commonwealth Office, Dudley House, 36 and 38 Southampton-street, London, W.C.2. Tel. TEMple Bar 8947.

Materials Handling Exposition, National.—Mon., April 29, to Fri., May 3, 1957, in the Convention Hall, Philadelphia. Apply to Clapp and Poliak Inc., 341 Madison-avenue, New York 17, U.S.A.

Factory Equipment Exhibition, Fifth.—Mon., April 29, to Sat., May 4, 1957, at Earl's Court, London, S.W.5. Theme: "Greater Efficiency in Industry." Organised by Factory Equipment Exhibitions, Ltd., 4 Snow-hill, Holborn-viaduct, London, E.C.1. Tel. CENtral 0354.

***Health Congress.**—Tues., April 30, to Fri., May 3, 1957, at Folkestone. Organised by the Royal Society of Health, 90 Buckingham Palace-road, London, S.W.1. Tel. SLOane 5134.

Caribbean Exhibition.—Fri., May 3, to Sun., May 19, 1957, at Port of Spain, Trinidad. Apply to the Junior Chamber of Commerce of Trinidad, Port of Spain, Trinidad.

Japan International Trade Fair.—Sun., May 5, to Sun., May 19, 1957, at Harumi Pier Grounds, Harumicho, Chuo-ku, Japan. Apply to Fair Management Office, Tokyo International Trade Fair Commission, c/o Economic Bureau, Tokyo Metropolitan Government, Marunouchi 3-Chome, Chiyoda-ku, Tokyo, Japan.

Industrial Tool and Production Show of Canada.—Mon., May 6, to Fri., May 10, 1957, in the Industry Building, Exhibition Park, Toronto. Apply to Mr. E. M. Wilcox, 19 Melinda-street, Toronto, Canada. (Alteration of dates.)

Engineered Castings Show, First; and the **61st A.F.S. Castings Congress.**—Mon., May 6, to Fri., May 10, 1957, at Cincinnati Music Hall, Cincinnati, Ohio, U.S.A. Sponsored by the American Foundrymen's Society, Golf and Wolf-roads, Des Plaines, Illinois, U.S.A.

British Industries Fair.—Mon., May 6, to Fri., May 17, 1957, in the B.I.F. Buildings, Castle Bromwich, Birmingham. Organised and controlled by the Birmingham Chamber of Commerce. Apply to the organisers: P.O. Box 6, 95 New-street, Birmingham 2. Tel. Midland 5021.

***Spring Show and Industries Fair.**—Tues., May 7, to Sat., May 11, 1957, in Dublin. Organised by the Royal Dublin Society, Ball's Bridge, Dublin.

Instruments, Electronics and Automation Exhibition, First.—Tues., May 7, to Fri., May 17, 1957, at Olympia, London, W.14. Promoted by the British Electrical and Allied Manufacturers' Association and four other trade associations. Organised by Industrial Exhibitions, Ltd., 105-106 New Bond-street, London, W.1. Tel. HYDe Park 9583.

Protective Clothing and Safety Equipment Exhibition, First.—Mon., May 13, to Fri., May 17, 1957, at Olympia, London, W.14. Organised by the U.T.P. Exhibitions Ltd. (Associate company of United Trade Press Ltd.), 43 Gerrard-street, London, W.1. Tel. GERrard 0727.

***Packaging Exhibition.**—Tues., May 14, to Tues., May 21, 1957, in the R.A.I. Building, Amsterdam. Organised by N.V. 't Raedthuys, 5 Tesselschadestraat, Amsterdam, Holland.

Book Exhibition, Second International.—Sun., May 26, to Thurs., May 30, 1957, at Sherman Hotel, Chicago. *Agent:* Mr. A. P. Wales, Dudley House, 36–38 Southampton-street, London, W.C.2. Tel. TEMple Bar 8947.

Waikato Agricultural Winter Show.—Tues., May 28, to Tues., June 4, 1957, in Hamilton, New Zealand. Apply to Mr. W. H. Paul, Box 616, Hamilton, New Zealand.

Bath and West Agricultural Show.—Wed., May 29, to Sat., June 1, 1957, at Swindon. Organised by the Bath and West and Southern Counties Society, 3 Pierrepont-street, Bath. Tel. Bath 3010.

Electronics in Automation, Convention.—In June, 1957, at King's College, Cambridge. Organised by the British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. Tel. MUSeum 1901.

Internal-Combustion Engine Congress, Fourth International.—Mid-June, 1957, at Zürich. Apply to Mr. C. C. M. Logan, secretary, British National Committee, 6 Grafton-street, London, W.1. Tel. HYDe Park 5107. See ENGINEERING, December 2, 1955, page 753.

***Printing Industries and Allied Trades, International Exhibition.**—Sat., June 1, to Sun., June 16, 1957, in Lausanne. Offices: 6 Avenue Mon-Repos, Lausanne, Switzerland.

***World Power Conference Sectional Meeting.**—Wed., June 5, to Mon., June 10, 1957. Trade Unions' Building, Belgrade, Yugoslavia. Apply to the British National Committee, 201 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 3966.

Three Counties Agricultural Show.—Tues., June 11, to Thurs., June 13, 1957, at Hartpury, Gloucester. Organised by the Three Counties Agricultural Society, Berrington House, 2 St. Nicholas-street, Hereford. Tel. Hereford 3969.

***Business Efficiency Exhibition.**—Mon., June 17, to Thurs., June 27, 1957, at Olympia, London, W.14. Organised by the Office Appliances and Business Equipment Trades Association, 11-13 Dowgate-hill, Cannon-street, London, E.C.4. Tel. CENtral 7771.

British Commonwealth Welding Conference.—Mon., June 17, to Sat., June 29, 1957, in London and Saltburn-by-Sea. Organised by the Institute of Welding, 2 Buckingham Palace-gardens, Buckingham Palace-road, London, S.W.1. Tel. SLOane 9851.

Commercial and Scientific Exhibition.—Mon., June 24, to Wed., June 26, 1957, at the Show Mart, Montreal. Held in conjunction with the 23rd Congress of the Catholic Hospitals of the Province of Quebec. Apply to the Comite des Hopitaux du Quebec, 325 Chemin Sainte-Catherine, Outremont, Montreal 8, Canada.

Exchange of Management Information, 11th International Conference.—Mon., June 24, to Fri., June 28, 1957, in Paris. Apply to the British Institute of Management, 8 Hill-street, London, W.1. Tel. GROsvenor 6000.

Royal Agricultural Show.—Tues., July 2, to Fri., July 5, 1957, at Costessey, Norwich. Organised by the Royal Agricultural Society of England, 35 Belgrave-square, London, S.W.1. Tel. BELgravia 5323.

***Great Yorkshire Agricultural Show.**—Tues., July 9, to Thurs., July 11, 1957, at Harrogate. Organised by the Yorkshire Agricultural Society, Cliftonfield, Shipton-road, York. Tel. York 3102.

***British Plastics Exhibition and Convention.**—Wed., July 10, to Sat., July 20, 1957, at Olympia, London, W.14. Apply to British Plastics Exhibition, Dorset House, Stamford-street, London, S.E.1. Tel. WATerloo 3333.

Electronics Exhibition and Convention, 12th Annual.—Thurs., July 11, to Sat., July 13, and Mon., July 15, to Wed., July 17, 1957, at the College of Science and Technology, Manchester. Organised by the Northern Division of the Institution of Electronics, 20 Buckingham-street, London, W.C.2. Apply to Mr. W. Birtwistle, 78 Shaw-road, Thornham, Rochdale, Lancs. Tel. Oldham Main 6661.

***Sydney Industries Fair.**—Mon., July 22, to Sat., Aug. 3, 1957, at the Sydney Showground, Sydney. Apply to the Industrial Public Relations Service of Australia, R.A.S. Showground, Box 5063, G.P.O., Sydney.

***Royal Welsh Show.**—Wed., July 24, to Fri., July 26, 1957, at Aberystwyth. Organised by the Royal Welsh Agricultural Society, Queen's-road, Aberystwyth. Tel. Aberystwyth 7551.

***Engineering, Marine and Welding and Nuclear Energy Exhibition, (21st) and the Foundry Trades Exhibition.**—Thurs., Aug. 29, to Thurs., Sept. 12, 1957, at Olympia, London, W.14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568. (Alteration of title of exhibition.)

Atoms Exhibition.—In August, 1957, at Geneva. Address of organising committee: 1 Place du Lac, Geneva, Switzerland. See ENGINEERING, December 16, 1955, page 816.

***British Trade Fair and Exhibition.**—Fri., Sept. 6, to Sun., Sept. 22, 1957, in Helsinki, Finland. Sponsored by the Federation of British Industries, the London Chamber of Commerce and the Finnish-British Trade Association. Supported by the Governments of Finland and the United Kingdom. Organised by British Overseas Fairs Ltd., 21 Tothill-street, London, S.W.1. Tel. WHItehall 6711.

Commonwealth Mining and Metallurgical Congress, Sixth.—Sun., Sept. 8, to Wed., Oct. 9, 1957, at Vancouver, British Columbia, and other centres in Canada. Apply to the congress secretary, 507 Metropolitan Building, 837 West Hasting-street, Vancouver 1, B.C., Canada.

***Marseilles International Fair, 33rd.**—Sat., Sept. 14, to Mon., Sept. 30, 1957, at Marseilles, France. *Agents:* Butler's Advertising Service, 22 St. Giles High-street, London, W.C.2. Tel. TEMple Bar 8905.

***European Machine Tool Exhibition.**—Sun., Sept. 15, to Tues., Sept. 24, 1957, at Hanover. Applications for space may be made to the Machine Tool Trades Association, Brettenham House, Lancaster-place, London, W.C.2 (Tel. TEMple Bar 3606). Other inquiries should be sent to Schenkers Ltd., 13 Finsbury-square, London, E.C.3. Tel. METropolitan 9711.

***Handicrafts, Homecrafts and Hobbies Exhibition, Fifth International.**—Thurs., Sept. 19, to Sat., Sept. 28, 1957, at Earl's Court, London, S.W.5. Apply to the exhibition's organiser, 24 Store-street, London, W.C.1. Tel. MUSeum 9792.

***Motor Exhibition, International.**—Thurs., Sept. 19, to Sun., Sept. 29, 1957, at Frankfurt. *Agents:* L.E.P. Transport, Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

***Fisheries Trade Fair, Second International.**—Fri., Sept. 27, to Sun., Oct. 6, 1957, in the Exhibition Hall Forum, Copenhagen, Denmark. *Agents:* John E. Buck & Co., 47 Brewer-street, Piccadilly, London, W.1. Tel. GERrard 7576.

In Parliament

THE LORDS SPEAK OUT ON ENGINEERING EDUCATION

It is, perhaps, characteristic of the differing functions of the two Houses of Parliament that, whereas, during the past few weeks, the Hungarian and Suez Canal crises have dominated the scene in the Commons, interest in the Lords has largely been centred on their debates on urgent industrial and technical problems in Britain. To one of these debates, on the effects of automation, we have already referred, on page 639 of our issue of November 16 last.

Another major debate took place last week, when Lord Simon of Wythenshawe (Labour) called attention to the much greater production of graduate engineers and scientists per thousand of the population in Russia and in the United States than in Britain, to the much greater effort devoted in those countries to scientific research, and to the inevitable effect which these trends would have upon the export trade and living standards of this country, if they continued.

No vision, he felt, was wanted now to see the almost desperate urgency of this nation's requirements for more engineers. He had been shocked to learn that his own firm, a moderate-sized engineering company, were spending at the rate of £20,000 a year on advertising for engineers and scientists, and not getting those they needed. The queue of firms wanting the right men had reached fantastic dimensions. At Cambridge, for example, eight men from the final honours physics school, free of national service, were last year faced with a total of no fewer than 1,034 vacancies, notified by 148 employers.

ENGINEERS NOT SCIENTISTS

Britain for a century was the leading engineering country in the world, but gradually fell behind as the others developed. In 1944, the Barlow Committee recommended that the number of scientists graduating from British universities should be doubled within ten years. With the help of the University Grants Committee, the universities went ahead and did a good job, doubling the number of graduates in three years, but little was done for engineers. For a time, the universities did nothing more and Britain fell rapidly and increasingly behind her leading industrial competitors. The crux of the position to-day was not scientists but engineers.

Another reason why the position had become desperate was the speed with which other countries were developing in science and engineering. This applied especially to Russia, who had been increasing her output of engineers by no less than 10 per cent. each year. In engineering education and in heavy industry, Russian progress had been remarkable.

The development of the steel industry in Russia had been an impressive and startling success. For instance, the Indian Government had placed orders for three steelworks, with Germany, Russia and Britain, respectively. The Russians sent out a very strong team and quickly produced a first-rate specification which greatly impressed the Indian Government. This was not to say that Britain's effort would not be as good—because it certainly would be—but the Russians were quicker off the mark.

CHALLENGE FROM RUSSIA

Under her present five-year plan, Russia was proposing to bring into operation each year new or extended steelworks with a total output of no less than 5 million tons and having an additional capacity each year. In four years her new capacity would be practically equal to Britain's present total capacity. The Ministry of Steel in Russia had a large designing staff which did nothing whatever except design steelworks; it had acquired immense experience and was clearly exceedingly efficient. This did not mean that Britain's steel industry was not efficient, because it undoubtedly was efficient. The best British steelworks were as well equipped as any in the world, but the scale and quality of Russian building and Russian management had greatly impressed both the missions sent to Russia from Britain's steel industry during the past twelve months.

In the electrical world, the Russians were technically ahead in certain directions. They had larger turbines at work, higher pressure boilers, and higher voltage transmissions. These were all steps in which Britain would be following in a few years. Scientists from this country had recently been shown an immense new nuclear machine, with a magnet weighing 36,000 tons, which would, when finished, be the largest in the world.

A leading member of the mission under Lord Citrine had told him, Lord Simon said, that Russian achievements in the aeronautical field, both civil and military, were comparable with those of the whole of the West. It had become apparent to that man that the Russians had the firm intention of competing in world markets with their civil aircraft and, under their political system, they would not find it difficult to offer their aeronautical products at competitive prices.

Evidence of the remarkable achievements by Russia was given in a recently-published report by a sub-committee of the United States Atomic Energy Committee. This compared the output of scientists and engineers in Russia and the United States, to the great disadvantage of the United States. This document stated in its preface that "it should be no secret that the United States is in desperate danger of falling behind the Soviet Union in a critical field of competition—the life and death field of competition in the education and training of adequate numbers of scientists, engineers and technicians." It suggested, therefore, that the time had come for strenuous measures by the Government, industry and the universities for what might be called a "crash program" to increase swiftly and steadily the number of adequately-trained American scientists and engineers.

That, coming from the United States, was somewhat strong.

ENGINEERS THE SURE FOUNDATION

One fundamental cause of Russia's success had been her terrific concentration on the education of physicists and engineers. Indeed, the number of graduate engineers might be the best single measure of the heavy industry effort. The engineers who mattered most were the university graduates, and those who had come up the hard way and made themselves equivalent to engineering graduates.

In Britain, the output of graduate engineers and their equivalent was not more than 7,000 a year, whereas the Russian total was 80,000 or more, and increasing rapidly. Russia was producing twelve times as many graduate engineers as Britain was, but her population was only four times the size of this country's. University engineering courses in Russia lasted for five and a half years. Students worked for ten months each year from the age of 17, after ten years at school.

Russia had made education for heavy industry her primary objective and, to that end, had spent money with the utmost freedom on everything necessary for the education of engineers—on buildings and equipment, and on scientific and technical staffs in schools, universities and technical colleges. Moreover, in Russia, engineering was one of the best paid of the professions. Professors of engineering, in great contrast with the practice in this country, were better paid than men holding the highest posts in industry. Russia had 250,000 science teachers while Britain had about 20,000.

Lord Simon said he would like to refer to one of Russia's engineering colleges. There were universities there which had no engineering faculty, of course, but there were also polytechnics and, when numbers became so large, the Russian authorities started mono-technics. One of these, he pointed out, had been described recently in ENGINEERING* by a British engineer. That was the Baumann Institute in Moscow, which had over 10,000 full-time students of mechanical engineering, a teaching staff of 700, and about 30 professorial chairs, including seven separate chairs for the study of different kinds of precision instruments.

Britain ought to spend within the next ten years at least £100 million of capital on her universities, that is, £10 million a year, and, said Lord Simon, he was not sure that that was enough.

GLOOM UNNECESSARY

It was the view of the Marquess of Salisbury, the Lord President of the Council, who spoke next, that there was no need to take too gloomy a view of the future. Russia's production, even in the fields of her greatest achievements, was still well below that of Britain per head of population and there were factors which seemed to indicate a possible slowing down in her rate of expansion. The number of engineers in Russia expected to graduate in 1960 would be about 90,000 and there were indications that that country did not intend to advance beyond that extremely formidable figure.

In Britain, the Ministry of Labour's recent *Report on Scientific and Engineering Manpower* had shown that qualified scientists and engineers were concentrated in relatively few industries. The total numbers were 56,000 scientists and 78,000 engineers, equivalent to 0·6 per cent. of the population. The equivalent figures for Russia and the United States were thought to be 0·85 and 1·2 per cent., respectively, of their working populations. The Government's Scientific Manpower Committee had concluded that the annual flow of persons qualified in pure and applied science should be raised from the present level of some 10,000 a year to about 20,000 a year by the end of 1970.

Lord Silkin (Labour) felt that science had for some years been something of a Cinderella. Parents who had ambitions for their children preferred the other professions. It was not entirely a matter of remuneration or prospects but largely a question of prestige.

A NEW INDUSTRIAL REVOLUTION

The Earl of Halsbury (Independent) said he had been told by no less an authority than a Nobel Prize winner that at least 18,000 tons too much steel had been used in the 36,000 ton Russian magnet. In connection with particle accelerators, it should not be forgotten that Britain was in a leapfrog race which was going on the whole time. There was always somebody ahead. At the moment Berkeley was ahead with a 6,000 million volt accelerator, but the great CERN project in Geneva would jump past that with 25,000 MeV. One of these accelerators was not built in England for policy reasons; Britain preferred to join in the co-operative effort in Geneva, but it should be remembered that the designer of that great project was a British electrical engineer.

The Earl of Home, Secretary of State for Commonwealth Relations, said that Britain should aim at a sufficient proportion of her young men being enlisted in science and engineering, but not necessarily the same proportion as in Russia, Germany or the United States. Unless the proportion was sufficient, Britain's standard of living was bound to decline. The shift in emphasis in national production since the war had amounted, in itself, to a new industrial revolution. In connection with the petrol-chemical industry, electronics and man-made fibres, the changes had occurred in a comparatively short time, but the revolution had gone only so far, because there was a shortage of qualified engineers and scientists.

The first necessity must be for the people of Britain, particularly the younger generation, to change their thoughts and habits. Their imagination, especially that of the young, must be caught by the prizes which a technical twentieth century could put within their grasp.

* See ENGINEERING, February 10, 1956, page 134.

THE HUMAN ELEMENT

Disciplines for the modern centaur—Russia produces twelve times as many engineers as Britain—Effects of the oil crisis—Lack of information causes strike—When the amateur needs the professional —I.L.O. call for independent trade unions.

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Human Engineering

An article by Mr. G. A. Peters in a recent issue of *Mechanical Engineering* (the Journal of the American Society of Mechanical Engineers) has drawn attention once again to the development of "human engineering." The author points out that as the movement towards automation gathers impetus, workers released by machines will have increasingly complex machines to control and operate. Since there will be increasing demands made upon the human factor in these man-machine systems, it is reasonable to expect that more and more attention must be given to those human factors which are brought into play to get the best response from the machines. In particular, more attention will have to be given, in the author's view, to the human aspects of design.

There has, of course, been a good deal of work done already on making human operations at the machine more natural and less conducive to creating physical and mental tension. Time and motion study has had just this aim in view. The arrival of automation on a larger scale may mean, however, that a more systematic attack will have to be made on the question involving the collaboration of several intellectual disciplines, and not just depend in its more straightforward problems on work study techniques or in its more advanced (and probably at present theoretical stages) on psychology. The author anticipates a coming together of a wide range of disciplines to develop "human engineering." This will take time if other instances of diverse disciplines coming together are any precedent. In the end, practical problems of automation may set the pace of progress, overtaking what, in the main, is so far a field for the theoreticians.

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Education Policy Under Fire

Lord Simon of Wythenshawe called attention last week in the House of Lords to the larger number of graduate engineers and scientists being trained per thousand of the population in the United States and the Soviet Union than in Britain and to the much greater effort devoted in these countries to scientific research. After more than a century of leading the world in engineering we were falling further and further behind, and it needed no great vision to see that if these trends were allowed to continue they would wreck our export trade and depress our standard of living. Lord Simon was particularly concerned with the spectacular progress made in Russia in increasing the output of engineers—by 10 per cent. per annum—and in developing a heavy industry which already outclassed our own. Russia, he said, was producing 12 times as many graduate engineers as we were though her population was only four times ours.

The Marquess of Salisbury, who replied to Lord Simon, admitted that the Russian figures were impressive but did not think there was any need for gloom on our part. The needs of the two countries were not alike, and in spite of her achievements Russia's output per head of the population was well below ours. Also there were signs of a possible slowing down of her rate of expansion, owing to the competitive claims of agriculture on available manpower. He received remarkably little support in the ensuing debate, during which several members endorsed Lord Simon's remarks and underlined his warnings. Viscount Cherwell was particularly scathing about the Government's policy on technical education. He called for technological universities and said that the Government did not appear to have appreciated the facts of the situation or to have a proper sense of urgency. A suggestion that the whole problem should be investigated by a small body of the three best brains in the country—he named two: Viscount Waverley and Lord Simon of Wythenshawe—was thrown in for good measure. Only Lord Woolton made the point that if industry wanted to recruit skilled technicians and first-class technologists, then it must make clear to the young the prospects it would offer them. Yet it is perhaps the greater recognition given to these men in countries such as the United States, Germany or Russia which ensures the right types move forward and that they are utilised to the best of their ability and potential.

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Without Oil, Without Work

The sudden cut in oil supplies has perhaps fallen hardest on those who service, fuel and man road transport vehicles, though the news from the motor industry suggests that it has fallen almost equally hard on those who make them. Garages have already announced that men will have to be laid off and others put on short time. One large company operating a chain of garages who employ 600 people are dealing with the emergency by stopping recruiting. Another, Blue Star Garages, who employ some 1,500 people in 150 garages estimate that they will have to dismiss more than 100.

It is too early to assess the effect of the cuts on the road haulage industry, which employs about 225,000 people. Some private hauliers estimate that their basic ration will keep their vehicles on the road for only one day a week, but are naturally anxious not to discharge workers until they know what the supplementary rations will be. At the end of last week the Ministry of Transport announced that goods vehicle operators who have applied for their basic ration could apply for supplementary rations at once instead of waiting until half their basic had been used. This will assist operators to decide how they will conduct their business during what may prove to be months of operating at two thirds of capacity.

The Government have had to act quickly, and it is not surprising to find that their actions have bewildered the road transport industry. Mr. A. R. W. Low's warning that the cuts may get worse reveal the full seriousness of the situation. Strike action will not help the drivers. The emergency in which the nation has suddenly found herself, wherever the blame may lie, requires unity and good will. This, and the strictest economy, will be needed to pull us through.

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Road Transport Illusions

The strike by B.R.S. lorry crews in the London area in response to the petrol cuts is a sad comment on public relations. It would appear that even in weeks when the Suez crisis has monopolised the news, its serious implications have made only a limited impact on the public. The men who stopped work were under the impression that the whole matter could be put right by a little better organisation of petrol supplies by B.R.S. which was presumed to have either a strategic reserve of petrol or could squeeze the necessary margin by better loading. The fact that the Government had ordered a 10 per cent. cut in the B.R.S. petrol allocation never percolated through the respective bureaucracies of the B.R.S. or the unions quickly enough to prevent strike action.

The blame for the incident must rest partly on the Government for failing to get the urgency of the petrol position across, partly on the B.R.S. partly on the Press which has failed to make impact on this subject, and partly on the British public which is always prone to discount or just not to read unpleasant news columns. Whoever is to blame this strike must surely be unique in trade union history. School children laugh at the story of Canute and the tide which happened over 1,000 years ago. In another 1,000 years are children going to laugh at people who thought they could conjure petrol out of nowhere by better organisation? Such an attitude of mind is by no means the monopoly of B.R.S. drivers. It is the other side of the coin (of which we are all so proud these days) that you can get better results by better organisation. Here is a small but significant example of modern shibboleths and systems being just as silly as ancient ones.

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Called to Account

Last year the trade unions paid out a record amount in strike money. This in itself is not a particularly noteworthy matter, for in an age of creeping inflation, records in money values are part of the nature of things. The statistics do however draw attention once again to the scale of modern trade union finance. The problem has been underlined by the alleged defalcation of £10,000 by the cashier of A.S.L.E.F. which was not detected by the lay auditors from the membership who checked the books.

These matters have now been aired in Part 4 of the Report of the Chief Registrar of Friendly Societies for 1955. It is apparent that the pace of progress in the adoption of modern accounting methods in the unions must be accelerated. The unions have built up their organisations on voluntary work to a large extent, with a core of professional officials. It is a system which has worked well in terms of devoted service to a cause. The time has come, however, when a compromise must be made with the size and complexity of modern problems.

Today the unions collect large sums of money. They have become large institutional investors with an interest in the equity of many industries. It is therefore inevitable that they should take professional advice on matters of finance and accounting. With this goes the corollary that trade union officials' salaries must bear some closer relation with the complexity and the financial responsibility which they carry.

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Workers of the World Unite

The reaction of trade unionists the world over to the Soviet Union's act of repression in Hungary has been prompt and remarkably direct. The indignation has not been limited to countries in the Western Hemisphere, but includes trade union bodies in many Soviet bloc countries and in the Far East. The Central Council of the Polish trade unions adopted a series of resolutions aimed at freeing their members from rigid Government and party control. This may well be the beginning of a movement which will grow as its needs become more clearly established and spread in the process, even into the Soviet Union herself. There is in it the unmistakable suggestion that even in a "workers' republic" the workers still require to organise themselves to bargain effectively for better conditions and higher pay.

Support for the Hungarian people came from the International Labour Organisation whose governing body voted by 36 votes to 2, with 2 abstentions, that Hungarian workers should be free to establish a trade union movement independent from government control. People need freedom to be themselves, and one freedom dearer than most is freedom from regimentation into universal drabness. Another is freedom from fear.